ENGINEERING

An Illustrated Weekly Journal

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ENGINEERING

An Illustrated Weekly Journal

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CAST FROM A NEW PATTERN

WITH this issue of ENGINEERING we have effected a major change in the layout and typography of the editorial pages. Since 1866, when the journal was founded, the four thousand five hundred and eighty-seven issues which have been published have conformed, in the main, to the same general arrangement. Minor modifications have been made from time to time, but every issue has been cast, if not from the original pattern, at least from one very like it. Now, on January 1, 1954, a new pattern has been made, and we present the first "off" to you, Sir, the reader, with reasonable confidence that it will accord with your taste and needs.

We have, indeed, studied your taste and needs. Would we be wrong to suggest, for example, that you agree that there is no profession to equal that of the engineer in interest, scope and the chance to produce something of value to mankind? That you are a specialist – whether as, say, a specialist in management or (for a few, mercifully short, years) in passing institution examinations? That you are alive to new ideas, and that you have the imagination, the experience and the intellect to seize upon and apply even those new ideas which, because they have been developed in fields of engineering other than your own, appear at first sight to be irrelevant to you and your work? If we are wrong in all these assumptions we are wrong also about this new layout and typography. But if we are right, then this is the first issue of many which will convey to your mind, week by week, ideas which only you can take up and develop in the particular way, and for the particular purpose, which your work and opportunities allow.

We recall a senior draughtsman who, though he was near retiring age, still retained his life-long habit of examining everything, however slight, of which the design and construction were not familiar to him. On one occasion, while we were walking through the works with him, he stopped abruptly and picked up what appeared to be a piece of scrap timber. Fixed to it, however, was a section of upholstery. His quick eye had seen that the method of fixing the upholstery to the timber was novel, and he made a mental note of it. He would not ignore something because it was apparently rather dull – like a piece of upholstery. But even engineering developments which are inherently interesting can pass unnoticed by engineers generally if they are not presented significantly. Engineering abounds in new ideas, new designs, new techniques and new products, and it is therefore our object to present them in such a way that the reader can at least equal his colleagues – and his competitors – in the facility with which he keeps abreast of them and uses them.

We do not pretend to be original in this approach, but we do believe that at least once in a generation the technique of presentation must be revised in the light of changed conditions. The founders of ENGINEERING, if they could visit 35 and 36, Bedford-street to-day, would no doubt be proud to find that their original pattern, with minor modifications, had served engineers and engineering for so long and so well. Almost certainly they would be surprised. If they were to browse through the 176 volumes which are to be found on the shelves of many scientific and technical libraries to-day, they could not fail to marvel at the tremendous tide of development which the columns of this journal have carried. After they had grappled with the science and art of engineering as we, in 1954, know it, and had failed to understand a tenth of what they saw and read, they would certainly begin to wonder whether it was even possible for their editorial pattern to have survived.

In making this change, therefore, we are not breaking faith with them, or betraying the trust which has been handed down from them to us. We are endeavouring to do, in 1954, what they did so well in 1866. Many factors have been taken into consideration, and in the years ahead we shall take in more. Like many other journals we acknowledge our debt to the newspaper and the typographer (Mr. Stanley Morison) who were responsible for the Times New Roman design introduced just over 20 years ago. We acknowledge also the valuable help of Harrison and Sons, Limited, the printers of ENGINEERING. Type design, however, is only a part of the production of a journal. The contents, week by week, must obviously determine its value to the reader. In that connection may we make one more assumption – that readers are more interested in the results than in any statement of policy? They will judge, from this and future issues of ENGINEERING, to what extent we succeed.

By a coincidence, the Council of the Institution of Mechanical Engineers have recently approved the publication of a new Institution journal with improved layout and typography, as reported on page 6 of this issue. Perhaps it is not a coincidence; maybe their change and ours are both signs of a growing realisation that journals arranged like the transactions of a Victorian learned society can no longer convey adequately the myriad messages of science and engineering in Twentieth Century Elizabethan Britain.

Weekly Survey

THE OUTLOOK FOR ENGINEERING

According to the latest statistics issued by the Board of Trade, the engineering industries did well in export markets in November, 1953. The figures given by the Board, and the general picture of British industry given in the December issue of the Treasury's *Bulletin for Industry* supplement, to some extent, the review which we commence on page 10 of this issue.

The course of production for British industry as a whole appears to have been according to the following pattern : a fall from the beginning to the middle of 1952 ; a full recovery by the end of 1952 ; the attainment by May, 1953, of a new peak level ; the loss of this level from June to August (partly because of people having a fortnight's holiday); and a new spurt in September and October, 1953. The Treasury's provisional conclusion is that the output of industry for 1953 may be some points higher than the previous peak achieved in 1951. This was the aim announced by the Chancellor in the Budget Speech, when he said we must do better than " make good the decline in output last year."

Crude steel production in November was an all-time record. For the first 11 months of the year the annual rate was 17·6 million tons, compared with 16·1 million last year and 16·4 million in the previous best year, 1950. Deliveries of finished steel have been running at about 7 per cent. above 1952, and no serious shortages now exist. Motor-car output in September and October was 38 per cent. higher than the average for those months in the two previous years. Commercial-vehicle output was at about the same level. Some types of industrial plant and equipment showed higher output figures in September than the year before, among them boilers, fuel-oil burners and furnaces, conveyors and elevators and machine tools. Others, however, have been falling, including industrial valves and works trucks. The value of factory buildings under construction at the end of September was the highest for two years, but was still 14 per cent. down on September, 1951.

The volume of United Kingdom exports up to the end of November, 1953, is expected to be about 3 per cent. greater than in the corresponding period last year. Volume is not, however, the same as value as there has been some decline in export prices. The value of United Kingdom exports in November amounted to £239·9 million. There were only 25 working days in November, but on a 26-day basis the figure was higher than in any previous month. Imports for the first 11 months of 1953 averaged monthly £278·7 million compared with £292·6 million in 1952. This decline of 5 per cent. was a consequence of a considerable fall in prices up to the middle of 1953. The volume of imports in the 11 months is estimated to be 10 per cent. more than in the corresponding period last year.

Exports of engineering products increased by 10 per cent., but a large part of this increase represented a recovery from the low figures recorded in the third quarter. In the five months July to November the monthly average of exports of engineering products was slightly less than in the first half year and still 3 per cent. below the rate in 1952.

The level of exports of electrical goods and machinery was lower in the five months than in the first half year, but vehicles were a little higher, mainly because of the record level of exports of aircraft. The value of exports of metals in October and November was nearly 10 per cent. greater at a monthly rate than in the previous quarter. This was the only major group the export performance of which did not substantially deteriorate in 1952. Average monthly shipments from July to November this year were more than in any previous half year.

Referring to imports, the Board of Trade state that prices have been much lower on the average, and substantial reductions, compared with 1952, in imports of iron and steel, and manufactures, machinery and cotton textiles are attributable in considerable measure to smaller defence requirements and, particularly in the first group, increased domestic production. The Treasury's Bulletin concludes the review of national production with the statement that " most of 1953's rise in production was derived from an increase in home demand, including some re-stocking – particularly of goods most affected by the recession in 1952 – and not from higher exports. Abroad, the picture is less encouraging. Whether production can be maintained and pushed to new heights in 1954 will turn, to some extent, on whether the trend of exports can be directed sharply upwards again." Which is substantially the conclusion reached in our Engineering Outlook article.

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AIRCRAFT PRODUCTION

With the trend towards supersonic speeds and the adoption of wings of smaller thickness/chord ratio, the aircraft industry has begun to find it necessary to break away from the light-gauge built-up skin-and-stringer structures that have been in use since the early 1930's, and to turn to structures with fewer components and joints in which the stiffening members are formed integrally with the skin plating.

At present, experience of such structures is based largely on components machined from solid billets, and in the United States, which has progressed farther in new constructional forms than has the United Kingdom, costly machine tools are under development to produce the complicated forms dictated by the necessity to keep structure weight to the minimum. Large forging presses up to 50,000 lb. capacity are also under development in the U.S.A., which will reduce the amount of machining required and will result in more efficient structures. At the aircraft production conference held in Southampton recently by the Institution of Production Engineers (a report of which is given on page 7) the problems of integral construction were among the matters discussed, and possible methods of tackling them without vast capital expenditure were suggested.

Criticisms by the users of aircraft, both military and civil, were also heard at the conference, and the remarks of the chief engineer of British European Airways, Mr. B. S. Shenstone, on the " poor standard " of workmanship in some British aircraft have attracted considerable publicity and some adverse comment. Vickers-Armstrongs Limited have issued a statement, with the authorisation of British European Airways, that their Viscount air-liners have given the Corporation full satisfaction. Sir Miles Thomas has said that British Overseas Airways Corporation could not substantiate Mr. Shenstone's view and that British workmanship is as good as any in the world. The Society of British Aircraft Constructors describe Mr. Shenstone's remarks as " unsubstantiated general criticism " and have asked British European Airways for details of the complaints to put before the appropriate technical committee. Sir Geoffrey de Havilland, in a letter to *The Times*, considers it " a pity . . . to have provided our competitors with an undeserved weapon . . ." The British aircraft industry has little to fear from its competitors so long as it maintains its unparalleled post-war record. Indeed, the fact that the national Press publicised Mr. Shenstone's remarks so widely was undoubtedly due to the fame of that record. But does this mean that every speaker at meetings of technical institutions must now guard his words lest they are taken out of their context and headlined throughout the world ?

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GRADUATES IN THE SHOPS

The discussion at the Institution of Mechanical Engineers last month on the best method for a graduate in mechanical engineering to fit in adequate training in industry revealed a general agreement that some form of " sandwich " system is preferred, both by the universities and industry. A year spent in a works immediately after leaving school gives the future undergraduate an experience of practical engineering and of working among men which is invaluable to him in the university. A further year in the works after he has graduated enables him to complete his general appreciation of practical engineering in relation to his academic studies. Extracts from the four papers are given on page 4 of this issue.

Opening the discussion, Mr. F. R. Livock, suggested that the universities should tell every accepted applicant that it was in his interests to spend a year in industry before going up to the university. Members of the Institution, he thought, had an obligation to guide the younger generation, and the most practical way of honouring that obligation was to act as personal tutor to one or two graduate or student apprentices in training. Mr. J. C. Jones remarked that war-stricken Germany had introduced a compulsory part-time day release scheme for all young people between the ages of 15 and 18 – " something which, despite two Acts of Parliament, we are still unable to afford." He made a special plea for the important minority of boys who left the higher forms of secondary school at the age of 18; if some kind of sandwich scheme could be offered to them the engineering industry would be doing something to attract valuable material from competing avenues of employment.

Mr. S. A. Wood said that at the Ministry of Supply there had been a trend away from part-time external degrees towards part-time training schemes; the accent was on associate membership of the Institutions rather than part-time degrees. Professor L. J. Kastner confessed that he had been a " victim " of the sandwich scheme. He was very much in favour of it, but it was essential for the young man to spend one whole day a week in a technical college during the pre-university year.

Mr. E. W. Greensmith, challenging the assumption that the graduate was to be trained only as an engineer, quoted the words of a leading American industrialist: " The broad extension of the area of use of the engineer beyond the professional operations of development and design has been one of the most important elements in the rapid increase in the industrial power of the United States. I am confident that our technological progress would have been much slower and our country's industrial strength of a considerably lower order if our technical education system had not supplied the large body of adequately trained engineers for use in the management and technical operation of an ever-increasing area. The top few levels of management of manufacture are largely filled by engineering graduates."

Letter to the Editor

A TUBULAR TRANSMISSION-LINE TOWER

Successful Method of Hot-Dip Galvanising

SIR. Your correspondent Mr. A. E. Percivall, in his letter on page 787 of your issue of December 18, 1953, shows a lively interest in the article on our tubular transmission-line tower (page 678, November 27), and raises some pertinent questions. The decision to test our tower in Italy was taken only after very full consideration of the testing facilities available in this country. The British testing equipment was quite unable to cater for the full height of tower which we considered desirable and, even with a reduced height, results could not be produced in the limited time we had at our disposal.

Facilities were not offered to expert personnel from the various British authorities since the test was viewed at this particular stage as being purely a private matter to supply us with sufficient technical data to enable us to go forward with confidence to those authorities for a final proving test in this country. It can be taken for granted that in any future tests all interested parties, particularly from the British Electricity Authority, will be welcomed.

Mr. Percivall, who obviously is an expert in transmission-line work, concedes in his letter that previous efforts to produce a high-voltage transmission-line tower of tubular construction have not been successful, and admits that the major problem has been hot-dip galvanising after fabrication. It is curious, therefore, to find him maintaining that " the object was to galvanise the tubes both internally and externally and so guarantee complete protection."

Open-ended tube gives no weight advantage whatsoever to tubular construction, since this material is subject to corrosion from both surfaces, and consequently comes under the minimum-thickness regulation normally laid down in tower specifications for the usual rolled sections. Sealing of all tubes is a fundamental principle in tubular construction because no internal corrosion can occur in the absence of free oxygen; therefore the major problem in tower work is to devise a method whereby a sealed tube can be effectively hot-dip galvanised. We claim to have solved this problem by a method which overcomes the danger of explosion in the bath and consequent risk to operators. For obvious reasons, the parts of the tower tested in Italy were not hot-galvanised, but the hot-dip galvanising process has been thoroughly tried out on sealed tubular tower members.

In regard to the test on the tower, only the actual working loads and 1·55 times the broken earth-wire loads were applied, as it was considered that, since we were only checking our design basis, the results from these tests would provide us with sufficient information to enable us to assess accurately the other load applications. As Mr. Percivall knows, the acme of tower design is the design of a structure which under any one of the five loading conditions he mentions would fail at the prescribed loading factor. Therefore, to do a test properly, five towers would be necessary and it would be interesting to learn if the tower now in use, to which he refers, was tested in this way.

We feel that the tests we have carried out to date have proved that our design methods are sound and that we are now in a position to proceed with the design and testing of a tower unit to fulfil the requirements of the authorities. It is appreciated that little commercial value can be attached to a tower of this nature unless it can be supplied and erected at a lower cost than its predecessors. The proof of the pudding is in the eating, and we are confident that with the inherent advantages of tubular construction, the methods of fabrication now at our disposal, the successful solution of the galvanising problem, and the technical knowledge we have gained from our investigation, we are now in a position to put forward an economic proposition. The fact that the export market has become one of intense competition should, we feel, only act as an incentive to British firms to take up the challenge with this new and formidable line of attack.

Yours faithfully,
TUBEWRIGHTS, LIMITED,
E. McMINN,
Chief Engineer.

Egginton House,
25, Buckingham-gate,
London, S.W.1.
December 18, 1953.

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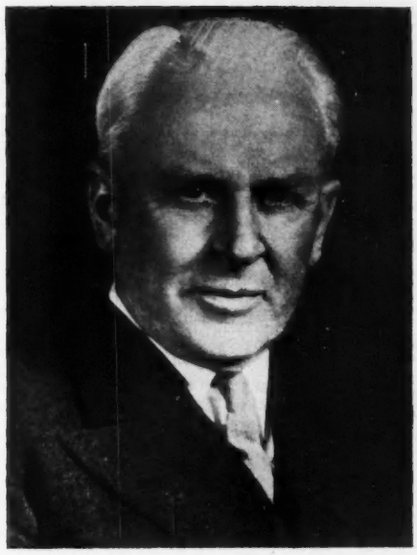
Obituary

DR. ROBERT A. MILLIKAN

Doyen of American Physicists



Physicists throughout the world will learn with regret of the death, on Saturday, December 19, at Pasadena, California, of Dr. Robert A. Millikan, who has been described as " the acknowledged doyen of American physicists." He was for many years Director of the Norman Bridge Laboratory and chairman of the Executive Council of the California Institute of Technology, becoming vice-president of the Board of Trustees of that Institute on his retirement in 1945. Although he spent much of his life at Pasadena, it is probable that he will best be remembered for the work he carried out while Professor of Physics at the University of Chicago. This work, for which he was awarded the Nobel Prize in Physics in 1923, was the determination of the charge on the electron, a quantity of fundamental importance in modern physics. It may be remembered that J. J. Thomson, at Cambridge, had previously determined $\frac{e}{m}$, the ratio of the charge to the mass of an electron, so that Millikan's work enabled both e and m to be correctly evaluated. His work on the determination of Planck's constant was also considered in making the award.

Robert Andrews Millikan was born at Morrison, Illinois, in 1868. He had thus reached the ripe age of 85 years. His early education was obtained at Maquoketa High School in Iowa and then at Oberlin College in Ohio. He obtained his Ph.D. at Columbia University where he spent two years on research work and afterwards studied for a short time at the universities of Berlin and Gottingen. On returning to the United States in 1896 he took a post as assistant in physics in the University of Chicago, where he afterwards held a professorship. It was there that he carried out his work on the electron.

On leaving the University of Chicago in 1921, Dr. Millikan was invited to become Director of the Norman Bridge Laboratory of the California Institute of Technology at Pasadena. Towards the end of the Second World War, Dr. Millikan wrote his autobiography, which we reviewed, in the form of a leading article, on page 145 of our 173rd volume (1952). In this book,* which is of exceptional interest and importance, he dealt with his own scientific work and that of many other scientists with whom he came into contact. One of the chapters is devoted to his early work at the California Institute of Technology and another to its projects for the future. He described the Institute " as a university, in the sense that it is developing a graduate school in which profound scholarship and the highest order of creative work are found " and as a college " in the sense that it confers the bachelor's degree and aims to cultivate intensively the humanities through devoting special attention to English, including literature, history and economics." He added that it was a technical school, in the sense that it attempted to give the men who passed through it such a cultural background and such a thorough training in the fundamentals upon which all engineering rests as would enable them " to take a more outstanding place in the progress of industry and science than would normally be open to them." We have quoted his descriptions of the Institute, of which he was for so long the Director, as they appear to us to throw a clear light on the character of the man.

He was interested in several British scientific societies, notably the Royal Society, which awarded him the Hughes Medal, the Royal Institution of Great Britain, of which he was an Honorary Member, and the British Association for the Advancement of Science, to which he presented a paper at the Winnipeg meeting in 1909. Dr. Millikan, of course, received honorary degrees from many American and European universities, as well as many awards from scientific societies in addition to those mentioned here. To list them would be merely tedious. His many publications, additional to his contributions to the proceedings of the learned societies, included works on physics, electrons and cosmic rays. His autobiography, we believe, was his latest work and perhaps his best. It certainly showed him to be a great man, as well as a great scientist.

* Published by Macdonald & Co. (Publishers), Ltd., London, 1951.

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We regret also to record the death of the following: MR. S. H. HEYWOOD, founder and chairman of S. H. Heywood & Co., Ltd., Reddish, near Stockport, at the age of 85. MR. J. HOGAN, until recently export sales adviser to British Insulated Callender's Cables Ltd., on December 14. MR. C. W. JONES, of the road contracts and quarries section of Thos. W. Ward Ltd., Sheffield, as the result of an accident, on December 15. MR. J. W. NAPIER, M.B.E., engineering manager of the Alloa Corporation Gas Department from 1902 until 1942, in Edinburgh, on December 16. MR. F. H. B. HARRIS, formerly chief draughtsman of W. G. Bagnall Ltd., locomotive builders, Stafford, in Canterbury, at the age of 82. MR. E. HARRISON, manager of the Cleveland by-products works of Dorman, Long & Co., Ltd., at the age of 62.

THE GRADUATE IN MECHANICAL ENGINEERING

ARRANGING PRACTICAL TRAINING IN INDUSTRY

A HELPFUL and lively review of the various ways in which a young man who is to take a university course in mechanical engineering can gain practical experience in industry was provided by a group of four papers presented at a meeting of the Institution of Mechanical Engineers on December 11. If the papers, and the discussion at the meeting, showed that there is no one ideal method, they were at least evidence that engineers in industry and the universities are constantly striving for better ways of ensuring that young engineers are given the right kind of opportunities and that engineering firms recruit men of the right character, training and education. Extracts from the papers are given below.

THE "1 : 3 : 1" COURSE

MR. KENNETH R. EVANS, O.B.E., M.A., M.I.E.E., A.M.I.Mech.E., who is manager of the education department of the Metropolitan-Vickers Electrical Company, Limited, remarks in his paper that a fortunate few [of the potential graduates] have been able to take a five-year course divided in the ratio 1 : 3 : 1 in works, university, works, following a full secondary grammar or public school education. The first "year" provides opportunity for a broad workshop experience while the post-graduate "year" includes that part of an apprenticeship during which it is necessary to have had extensive theoretical training.

An essential part of the practical engineering training of graduates [in former years] was the opportunity for intimate contact with the "men on the floor of the shop," as well as with all grades of supervisor, technician, and technologist. The extent to which this is now necessary in time is possibly less because of the social experience obtained during compulsory military service. It is appreciated that the industrial earnings a young man loses when he commences military service immediately on attaining the age of 18 are less than those he forfeits during the period of military service after the completion of his full training at university and during apprenticeship. This, however, is the only disadvantage of postponing military service. An important advantage of deferment is that the trained engineer will be able to ensure that he carries out his military service in an appropriate section of the Royal Navy, Army, or Royal Air Force.

At present, the majority of young men who leave school with the intention of following a university course proceed direct, but some universities require candidates for the engineering faculties to have completed military service with the intention that they shall go up to the university more mature and experienced.

The opinions of young men who have followed the sequence of 1 : 3 : 1 years of workshop and university work have been, subsequent to their training, that, without exception, they were glad they had adopted this arrangement rather than direct entry to the university.

The value of pre-university training, followed by one year of practical training, is that the firm recruiting well-equipped young men for this course must arrange a carefully planned training course of workshop experience for what is, in practice, a period of ten months, from the early part of September until the end of July. During this time they are required to pursue a course of studies at local technical colleges in a revision and expansion of their knowledge of pure physics, chemistry and mathematics at "advanced" level.

Vacation periods extend their experience to equip them for positions of technical and executive responsibility in later years, whether these periods are spent with the parent company or, as is recommended, in obtaining experience in generating stations, foreign travel, etc. Such a five-year period after the young man has left school provides an opportunity for a full life in every respect.

The post-graduate apprenticeship period of 14 months, which completes the apprenticeship, provides for experience in test beds, and in drawing offices, design offices, works' planning, commercial departments, and research sections, and is arranged with a bias towards the type of work in which the young man hopes to specialise on appointment to a junior staff position.

Apprenticeship period requires relaxation, and many of the recommendations made provide for it by change of occupation—which makes for relaxation. Private reading of technical journals, papers, and literature, whether fiction, poetry, travel, or autobiography, should have a claim on some part of a young man's time.

What has been said about the training of those who enter industry after leaving school prior to joining the university, applies equally, in principle, to those who proceed direct to the universities or who commence their five-year training as mechanical engineers on the conclusion of military service, when this is commenced immediately on attainment of the age of 18 years. It is not recommended, however, that those who elect to do military service at 18 years of age shall follow pre-university practical training; rather, they should proceed direct to the university. They will have acquired a knowledge of a cross-section of their fellow-men, outside the sheltered conditions of school life, which it is desirable to acquire early and for which the pre-university course of training provides. Being older they should not further delay their entry into academic studies.

It is the experience of many young men who have accepted an immediate staff position, with greater remuneration than that paid to post-graduate apprentices, that in two or more years they are handicapped. They must accept loss of earnings, but appreciate the need for a broad platform of knowledge and experience upon which to build the pyramid of their future career which tends, in the majority of cases, to be a "regular figure" in that its height is proportionate to its base line.

THE "SANDWICH" SYSTEM

MR. H. W. FULTON, B.Sc., M.I.Mech.E., who is managing director of Albion Motors, Limited, points out in his paper that in Scotland the traditional form of engineering apprenticeship still persists almost universally. In parallel with this, engineering schools at Glasgow University and elsewhere provide training to enable young men to graduate in mechanical engineering. The system which has been operated for many years in the West of Scotland is that university courses are carried out during the winter six months; during the summer six months students work as apprentices in engineering works. This system has the full approval both of the engineering employers and of the engineering schools, and has served so well that it would be hard indeed to get this so-called "sandwich" system altered.

The full-time student who enters an engineering works only at the conclusion of his degree course will find himself at a pronounced psychological disadvantage compared with those of the same age who have already acquired considerable shop experience. He will also have had to pursue his engineering studies to some degree "in a vacuum," because he will not have had the opportunity of observing in operation the practical application of what he has been studying.

An argument may be put forward that the "sandwich" system permits little relaxation to the student, but it is not felt that this is valid. It is known that the best form of relaxation is alternative occupation, and a system whereby six months of what is essentially brain work alternates with six months of essentially physical work does provide a high degree of relaxation.

POST-GRADUATE APPRENTICESHIP

MR. R. S. MEDLOCK, B.Sc., A.M.I.Mech.E., and MR. D. P. LANT (chief research and development engineer, and chief project engineer, respectively, of George Kent, Limited) state in their paper that the increasing number of highly-qualified men required by industry has intensified the demand for recruits having a capacity for rapid learning and adaptation. Full-time university graduates have had opportunities to acquire these qualifications and come to industry well equipped with a scientific approach and background of theoretical skill which can be quickly moulded to suit the particular branch of engineering they enter.

They are not faced with the larger task of learning the theory and acquiring the technique of practice at one and the same time. Thus, they have opportunities to develop more completely. They may also have the social graces and self-confidence which make their path of progress easier.

It is generally agreed that graduates are handicapped in later life if they fail to receive adequate general training in industrial engineering before accepting a responsible post. A large proportion of engineering firms that recruit graduates thus provide an organised post-graduate apprenticeship of about two years' duration.

As with every apprenticeship or other training scheme, there are three vital stages: selection, training, and placing. Failure in any one must bring a failure to the scheme as a whole, and when one considers the expense involved in post-graduate training schemes, it is vital to the firm concerned that everything possible is done to ensure reasonable success in all three stages.

A graduate apprentice's practical training should be organised to provide a general background, slightly biased with a view to the type of position he is ultimately expected to hold. Broadly speaking, graduates in industry tend to specialise as production engineers, sales engineers, or research engineers. Each training programme should be "tailored" to meet the needs of the individual concerned.

Since the training programmes are largely carried out through the medium of various departmental heads, it is most important to secure their full co-operation. This will be achieved only if the training policy is clearly

defined and adequately backed by the board of directors, and suitably executed by a co-operative, but firm, training department, the head of which is recognised as an authoritative person. Early specialisation, apart from the slight bias of training along one of the three main branches of production, sales, or research, is definitely to be discouraged.

All graduate apprentices should regularly complete a report on the type of work they have been doing; perhaps a weekly report. These reports help the apprentice to crystallise the events of the week in his mind and also help the apprentice supervisor to ensure that the training maintains a reasonable balance of experience. There might, however, be a temptation to encourage the graduates to include remarks on points of possible improvement, and general criticism on the efficiency of the departments through which they pass. This would be most inadvisable, if the vital co-operation of heads of departments is to be improved and maintained.

One of the aims of a graduate apprenticeship scheme is to develop the latent abilities of those who may eventually be capable of qualifying for managerial positions. Thus, particularly, those specialising on production, may be encouraged to follow either the course in Industrial Administration and Workshop Organisation for Section C of the professional institutes' examinations ; or to embark on the rather more ambitious three-year course, leading to the Intermediate Certificate in Management Studies, planned under the recommendations of the Urwick Report on Education for Management. Special " graduate courses " are held at Ashridge.

It must be recognised that the first-class honours man with a good leadership capacity should be given the opportunity, if he proves himself, to rise to somewhere near the top very rapidly; even if this does occasionally mean upsetting, or even displacing, the long-established but less adequate man.

The firm which really takes this matter seriously should have a committee set up at the highest executive level to analyse carefully the firm's managerial, supervisory, and technical structure, to pin-point its weaknesses in quantity and quality, and to evaluate its effectiveness and outline its future. It should then make a clear statement of what call there is, or will be, for potential managers, supervisors, sales representatives, application and research engineers, first-grade service and contracts engineers, methods engineers, cost control personnel, and many others.

Such a committee may also take the responsibility of " placing " graduates and outstanding students at the end of their training, to ensure that they set their feet at the bottom of the right ladder.

LIAISON BETWEEN UNIVERSITY AND INDUSTRY

Professor J. A. Pope, Ph.D., D.Sc., Wh.Sc., M.I.Mech.E., who is Professor of Engineering and Head of Civil and Mechanical Engineering Departments, Nottingham University, states in his paper that an engineer is essentially concerned with service to the community. Before his ideas can pass from the drawing board and develop into reality, he must possess the ability to infuse in others his own vision and confidence, and have adequate executive skill to co-ordinate the production of the commodity. The complete training for the professional engineer is a balanced course of scientific training and practical experience.

Owing to the rapid advance of science during the first half of the Twentieth Century, it has been necessary to increase the scientific content of the engineering course. This has been achieved by omitting workshop practice almost completely, while the time allotted to machine drawing has been reduced so that, although a graduate is able to read a drawing, the quality of his draughtsmanship is rarely satisfactory.

The universities do not train engineers; they train students in engineering science and it is left to industry to complete the graduates' training. The larger engineering firms have been aware of this change and have developed graduate training schemes designed to meet this need. To-day the most common pattern for training the graduate engineer is : direct from school to university for a three-year course, followed by a two-year graduate apprenticeship with one of the larger engineering firms. This system has the advantage that it is simple and easy to administer. It might be well, however, to ask two questions: (1) could better results be obtained by having the two sections of an engineer's training somewhat co-ordinated instead of being so completely disconnected ? (2) Are the best results obtained in the majority of instances by allowing the undergraduates to come direct to the university from school and receive the whole of his practical training after graduation ?

In the author's opinion, the answer to the first question is in the affirmative and the second in the negative. The following slightly modified pattern of training is worthy of serious consideration. (1) An applicant having obtained the appropriate requirements for admission to a university is jointly selected by the university and the firm with which he will receive his practical training. (2) The successful trainee then joins the firm for twelve months as a normal apprentice, receives the works aspect of the practical training, and is released for one day per week for further education at a convenient technical college. He receives a guarantee, prior to entering the firm, of admission to the university at the end of this year subject to his progress having been satisfactory. (3) After successfully completing his degree course the graduate would return to the firm for a further year to complete his practical training, this time to gain experience in the technical and executive aspects of the profession.

Under present conditions, when over the past few years the output of engineers by the university has been doubled, a greater proportion of graduates is being employed on production. Industry itself, however, has its own trainees, who, entering at about sixteen years of age, have endeavoured to better themselves by part-time release and evening study. These young men may quite naturally feel some resentment at the injection of the degree men into posts which form the objects of their ambitions. Furthermore, it is not easy for the new graduate and the craftsman to work side by side, and even though it may be good for the graduate to overcome a certain amount of resistance, is it in the interest of industrial relations ? If, however, a boy enters the works direct from school, he will be much more acceptable to the men. Should he eventually proceed to a university and, after completing his course, return to the firm, he will be much more readily absorbed on production, as he will be regarded as " the boy who got on from the bench."

The best intellects of the nation must be given time to think during their adolescence. For this reason it is doubtful whether it is wise for graduates to have industrial employment in every long vacation. One, at least, should be spent abroad to widen their interests and outlook. This is perhaps more important to-day than ever before, because a larger proportion of the graduates is coming from homes where facilities for travel and a general appreciation of scholarship are not possible.

PERSONAL

Lord Bennett of Edgbaston, C.B.E., having completed a year in office as chairman of the British Productivity Council, 21, Tothill-street, London, S.W.1, has been succeeded by Mr. Tom Williamson, C.B.E. Lord Bennett, however, will remain a member of the Council. Sir Lincoln Evans, C.B.E., who earlier this year was appointed vice-chairman of the Iron and Steel Board, has been succeeded as deputy chairman by Sir Ewart Smith.

The Minister of Supply has appointed, as Controller of Atomic Weapons, Lieut.-General Sir Frederick Morgan, K.C.B., who has been Controlller of Atomic Energy in the Ministry since 1951.

Mr. G. H. Latham, chairman and managing director of the Whitehead Iron and Steel Co. Ltd., has been appointed President of the British Iron and Steel Federation, Steel House, Tothill-street, London, S.W.1, in succession to Sir Ellis Hunter, who has been President since 1945. Mr. A. G. Stewart has been appointed president elect of the Federation.

Mr. Frank Thompson-Schwab, chairman, Sir Alexander Dunbar, deputy chairman, and Mr. Hugh Quennell, a director, of Darwins Ltd., are joining the board of the Sheffield Forge and Rolling Mills Co. Ltd., the entire share capital of which has been acquired by Darwins Ltd. Mr. Frank Thompson-Schwab has been made chairman.

As from to-day, January 1, Mr. E. O. Measor, A.C.G.I., B.Sc., M.I.C.E., and Mr. H. Grace, M.Sc., M.I.C.E., partners in the firm of Scott and Wilson, have joined, as partners, Mr. R. W. Hawkey, M.A., M.I.C.E., M.I.W.E., the sole partner of the firm of Sir Cyril Kirkpatrick and Partners. Henceforth, the practices will be continued under the title of Scott and Wilson, Kirkpatrick & Partners. Also on January 1, Mr. F. M. Bowen, M.I.C.E., A.M.I.Struct.E., is being taken into partnership. From Monday, February 15, the address of the firm will be 47, Victoria-street, London, S.W.1.

Mr. C. E. King has relinquished his position as a director and director of engineering of Vauxhall Motors Ltd., Luton, Bedfordshire, owing to uncertain health, but has agreed to remain available as an engineering consultant.

Major-General C. A. L. Dunphie, C.B., C.B.E., D.S.O., of Vickers-Armstrongs Ltd., Mr. J. W. Platt, of the Anglo-Saxon Petroleum Co. Ltd., and Mr. W. F. Wackrill, O.B.E., of the Esso Transportation Co. Ltd., have been elected members of the General Committee of Lloyd's Register of Shipping, 71, Fenchurch-street, London, E.C.3.

Colonel A. C. R. Waite is relinquishing the deputy chairmanship of the Austin Motor Export Corporation, and has reassumed the post of London director of the Austin Motor Co. Ltd., 479, Oxford-street, London, W.1.

Mr. W. E. P. Johnson, A.F.C., A.F.R.Ae.S., C.P.A., is relinquishing the joint managing directorship of Power Jets (Research and Development) Ltd., but will continue with the company as an adviser. Mr. T. G. Hicks, M.A., C.P.A., joint managing director of the company since May 1, 1953, becomes managing director with effect from to-day, January 1, 1954.

Mr. J. B. Bryce, hitherto Liverpool marine branch manager, Vacuum Oil Co. Ltd., is succeeding Mr. G. M. McGavin as chief marine engineer in London. Mr. McGavin is taking up special duties. The new Liverpool marine branch manager is Mr. R. O. Keyworth.

Mr. E. S. Waddington, F.S.E., M.Inst.W., A.I.E.E., has been appointed honorary treasurer of the Society of Engineers.

Mr. Philip Jones has been appointed to the new position of Press and Publicity Officer of the Exports Credits Guarantee Department, his address being 9, Clements-lane, London, E.C.4. (Telephone Number Mansion House 8771.)

BUSINESS CHANGES

Following the acquisition by Hattersley (Ormskirk) Ltd., Ormskirk, Lancashire, of 75 per cent. of the share capital of Beck & Co. (Meters) Ltd., in issue, Mr. H. C. Nicholson, J.P., F.C.A., deputy chairman, and Mr. W. J. Lee, A.C.A., assistant managing director, of Messrs. Hattersley, have been elected to the board of Messrs. Beck, while Colonel C. A. Hunt, M.C., T.D., and Mr. T. P. A. Galloway, joint managing directors of Messrs. Beck, have been elected to the board of Messrs. Hattersley.

Dawe Instruments Ltd., 130, Uxbridge-road, Hanwell, London, W.7, are shortly to move into more extensive premises at 99, Uxbridge-road, Ealing, London, W.5.

RAILWAY ACCIDENTS IN 1952

The report of the Chief Inspecting Officer of Railways (Lieut.-Colonel G. R. S. Wilson) to the Minister of Transport and Civil Aviation, upon the accidents which occurred on the railways of Great Britain during 1952, discloses that 111 passengers were killed in train accidents. This was over three times the average figure for the 1946-50 period and is to be explained by the double collision at Harrow, in which 112 persons (including four railway servants) lost their lives. Had it not been for this, only one passenger would have been killed in a train accident. In addition, 52 passengers were killed in other accidents. The fatal casualties among railway servants amounted to 200, only nine of which were caused by train accidents, while 13 " other persons," excluding trespassers and suicides, suffered in the same way and 39 in other accidents. None of these figures differed greatly from the average of the 1946-50 period. The Harrow disaster was also responsible for a large increase in the number of passengers injured in train accidents, although the figures under the other headings were about the average. There was some decrease from the average in the non-fatal accidents to railway servants and a slight increase in those to " other persons " under this heading. The total of 386 fatalities in " all movements by rail " was equivalent to 0·9 per million train miles.

PROGRESS IN OPERATING EFFICIENCY

Generally speaking, Colonel Wilson reports, the year was one of steady progress in operating efficiency and modernisation of equipment. The supply of steel and other basic materials became easier towards its close and there was again a slight improvement in the strength of the track maintenance staff. Arrears in the renewal of locomotives, and particularly of rolling stock, had still to be overtaken, but the position gave no ground for anxiety. Progress in the restoration of the track to its pre-war standard was continued; with the result that it was possible to accelerate some express passenger trains and to reduce the number of speed restrictions.

As regards the causes of accidents, few of those of any consequence could be attributed directly or indirectly to inadequate or worn-out equipment, their predominating cause being the failure of individual members of the staff to measure up to their responsibilities in the course of operation or routine maintenance or even to concentrate their attention on simple duties. This does not suggest, it is emphasised, that there is any general recession from the strong sense of duty which is characteristic of British railway men, but there are some men, perhaps more than formerly in certain localities, who do not appear to have absorbed the traditions of railway service. This is attributed partly to the difficulty of finding men of suitable character and qualifications for responsible posts in competition with other forms of employment; and partly to factors which affect the morale and self-discipline which are so important to railway safety and which depend on training, supervision of the right kind and leadership.

Nevertheless, with the best will in the world the human element will always be fallible, as is shown by the fact that 565 accidents, or 45·5 per cent. of the total, were due to this cause. Automatic train control of the warning type would probably have prevented the Harrow accident and the British Transport Commission have therefore decided to extend it progressively to all the more important routes in the country.

ENGINEERING CENTENARIES IN 1954

PARSONS, OHM AND MURDOCK

In a review of the centenaries that occur in 1954 which are of interest to engineers, that of the birth of Sir Charles Parsons naturally comes first. He was born on June 13, 1854, at 13 Connaught-place, Hyde Park. " At his birth," wrote his biographer, Rollo Appleyard, " the fates bestowed upon him wealth, health, and the most refined and abundant means of acquiring wisdom. He responded by devoting these gifts to the welfare of mankind."

He died on February 11, 1931, on the S.S. Duchess of Richmond in Kingston Harbour, Jamaica, and was buried at Kirkwhelpington, Northumberland, where there is a memorial to him of marble from his Irish home and stone from his Ray estate, nearby. No less gifted were his contemporaries, Henry Selby Hele-Shaw (1854-1941) and Sir Richard Tetley Glazebrook (1854-1935), the latter of whom was the Director, from 1899 to 1919, of the newly-founded National Physical Laboratory and from 1920 to 1923 Zaharoff Professor of Aviation and Director of the Aeronautics Department of the Imperial College. Parsons and Glazebrook were Cambridge men and Wranglers, but Hele-Shaw began as an engineering apprentice at Bristol and fought his way upwards by the aid of Whitworth Scholarships, becoming the first professor of engineering in University College, Bristol. From there he went to Liverpool and then to the Transvaal. At Liverpool he made his experiments on the streamline flow of liquids. His later years were devoted to the development of his many inventions, lecturing at institutions, and to his work as president of various societies.

In marked contrast to the early environment of these three eminent men was that of the German-American watchmaker Ottmar Mergenthaler (1854-99) and the American bank clerk, George Eastman (1854-1932), the former of whom, after long years of labour, brought to perfection the linotype machine. The latter, in 1884, patented the first commercially successful rollable photographic film and in 1888 produced the original Kodak camera. Both became wealthy men, and Eastman, it is said, gave more than 75,000,000 dols. to various philanthropic objects. Mergenthaler only lived to the age of 44, but Eastman was in his 78th year when he died, by his own hand.

In the list of men who died a century ago are the names of Lloyd, Manby, Ohm and Melloni. John Augustus Lloyd (1800-54) in his 'twenties served in South America under Simon Bolivar, who sent him to survey the Isthmus of Panama, a work which led to Lloyd's paper of 1849 to the Institution of Civil Engineers entitled " Facilities for a Ship Canal between the Atlantic and Pacific." Severely wounded, he was back in England in 1830 and in the next year became Colonial Civil Engineer to Mauritius, where he spent 18 years. In 1854 he was sent on a mission to the Crimea and died there of cholera. Captain George William Manby (1765-1854), like Lloyd, was connected with Norfolk. As a youth, he fired a line over a Norfolk church tower by means of a mortar. Trained at the Royal Military Academy, Woolwich, he was serving in 1803 as barrack master at Yarmouth where, five years later, he used the same method of line-throwing to save the crew of a wrecked ship. His ideas were adopted by the Government, from whom he received in all £7,000.

Every engineer, if he cannot now recall it precisely, has heared of Ohm's Law, first enunciated in a pamphlet in 1827 by the German physicist Georg Simon Ohm (1787-1854) when he held a chair at Cologne. His views failed to gain much recognition until the Royal Society, in 1841, awarded him the famous Copley Medal. At the time of his death he was professor of experimental physics at Munich. His Italian contemporary, Macedonio Melloni (1798-1854), after being a professor at Parma, was for some years a refugee in France, but in 1839 returned to Naples and long directed the observatory on Vesuvius. It was his pioneering investigations on radiant heat which brought him fame and for this work the Royal Society awarded him the Rumford Medal. With his countryman Leopoldo Nobili (1784-1835) Melloni perfected the thermo multiplier or thermopile.

The name of William Murdock (1754-1839) conjures up the great days of the famous Birmingham works of Boulton and Watt, which he entered in 1777. The finest erector of engines in his day, he made a model steam-driven vehicle, was the chief pioneer of gas lighting and also of the use of compressed air for driving machinery. The D slide valve was another of his improvements. The cottage in which he was born at Lugar, Ayrshire, the house he occupied at Redruth, Cornwall, and the Wallace Memorial at Stirling all bear memorials to him, the last of which was unveiled by Lord Kelvin in 1892. Murdock, like Boulton and Watt, is buried in Handsworth Church, Birmingham.

A NEW I.MECH.E. PUBLICATION

" THE CHARTERED MECHANICAL ENGINEER "

The Institution of Mechanical Engineers have decided to start a new publication, *The Chartered Mechanical Engineer*, which will supersede the existing *Journal* of the Institution The main function of the *Journal* was to acquaint members with the various activities of the Institution, but the new publication will, in addition, contain a high proportion of technical information such as lectures and addresses.

The change in publications policy has enabled the Council to review the presentation and styling of the Institution's printed material, and the first results can be seen in *The Chartered Mechanical Engineer*. The papers and other material are now more readable. It will be published monthly except in July and August.

Arrangements for publishing the *Proceedings* of the Institution are also to be altered. Publication of the existing *Proceedings* (A) and (B) and *Automobile Division Proceedings* will cease, as such, in due course, but each paper will appear in full with its discussion as a separate issue of *Proceedings* (to be supplied to members on demand), thus materially speeding up final publication. The Council have also decided to publish and to issue to all members (numbering about 40,000) summaries of papers accepted for publication. These summaries will appear in *The Chartered Mechanical Engineer* some four to eight weeks in advance of meetings at which the full papers will be presented. They will run to a length of about 1,000 words.

MATERIALS, METALLURGY AND MACHINING

A LEAD FROM AIRCRAFT ENGINEERS

Aircraft designers and production engineers met at Southampton University on Friday, December 18, and Saturday, December 19, to discuss problems of aircraft and equipment production. At the opening luncheon they were welcomed by the Mayor of Southampton, Alderman Mrs. V. F. King, J.P., and by Lord Hawke, representing the Minister of Civil Aviation. The conference was divided into four sessions, concerned with design trends, production problems arising from them, problems of the user, and a summing-up of the whole proceedings.

The conference was organised by the southern section of the Institution of Production Engineers.

THE TREND OF DESIGN

In the opening paper on "The Trend of Design," Mr. David Keith-Lucas discussed the effects of designing for high speed on the aircraft configuration, internal equipment, structural design, and materials of construction.

He showed slides representing possible layouts for an aircraft designed to fly at twice the speed of sound; one had a thin straight wing, with a thickness/chord ratio of 3 to 4 per cent. Such a wing was useless for storage, and the engines were therefore shown at the wing tips. The undercarriage would have to retract into the fuselage. Alternatively, a delta layout with a sweepback of about 80 deg. could be adopted; it appeared to be simpler structurally, and better adapted for stowing fuel and the undercarriage. Again, wing-tip engines were suggested, since if they were enclosed in the wing roots the duct losses would be unacceptable. Little, however, was known about the control characteristics of such a wing, and for long range it appeared to be less efficient. Stowage capacity within the aircraft was likely to decrease with the desire for minimum frontal area, whereas engine power and fuel capacity must increase to provide the higher speed. Equipment, moreover, was becoming more complex and extensive. Some rationalisation and simplification would soon become essential.

In structural design, the trend was towards fewer parts with fewer joints. "Integral construction"—in which the skin and stringers were machined from a single slab—resulted in a saving in weight and cost, and a superior surface finish compared with a riveted construction. In high-grade materials, problems of cracking and distortion might arise. The logical development of integral construction for wings was to eliminate ribs and use multiple spanwise webs. This would pose a production problem since accessibility for assembly would be limited.

The use of Redux bonding in place of riveted construction resulted in better fatigue properties, greater compressive strength, and a better surface finish. It also facilitated the use of more efficient closed-section stringers, in place of Z-sections. The aluminium honeycomb, used either as a double skin "sandwich" or as a complete filler between the outer skins, showed promise for structures in which the end loads were of fairly low intensity.

The increase in strength of aluminium alloys was approaching the limit of usefulness, since much of the aircraft structure was now designed for stiffness rather than strength. High-strength aluminium alloys, moreover, had poor cross-grain properties and their doubtful notch-fatigue resistance demanded meticulous surface finish and no scratches. In addition, their fatigue resistance did not increase proportionally with their ultimate strength. In steels, the ratio of fatigue to ultimate strength was more nearly constant, and high-tensile steels with ultimate strengths of 280,000 lb. per square inch were under consideration in the United States. Titanium was a good structural material and retained its strength at high temperatures. At present, its properties were not yet sufficiently consistent, and it was difficult to work. Resin-bonded glass laminates had excellent tensile properties but were not good in shear and compression; they could, however, be moulded, and, properly understood, the strength of the moulding could be disposed as the designer wished, resulting, in some cases, in lighter structures.

PRODUCTION PROBLEMS

At the evening session, which was concerned with "Production Problems Arising from the Trend of Design," the chair was taken by Mr. W. Browning. The first paper, by Mr. G. H. Dowty, who was ill, was read by Sir Roy Fedden. He discussed the production problems of an equipment manufacturer, which, he said, fell into two categories, associated with equipment designed for a particular aircraft, subject to many modifications, and with standardised equipment of stabilised design such as pumps, control valves, and instruments. As an example of the first category, thin wings had increased the difficulty of stowing the retracted undercarriage; jet engines had led to shorter undercarriages, and at the same time higher landing speeds called for greater shock absorption. With the more complex designs resulting from these considerations the need for weight control and dimensional accuracy had led to the practice of machining fittings all over and to the use of stronger materials such as 100-ton steels. In general, where production fittings were made from forgings, it was necessary to machine away some 60 per cent. of the billet, whereas if castings were used, only about 9 per cent. of the material had to be removed. Castings, however, being of lower strength, involved a weight penalty in many applications.

Among the improved machining techniques adopted recently by Dowty Equipment, Limited, were high-speed fast-feed milling using a tungsten-carbide blade cutter; accurate rough machining before final heat-treatment to reduce final machining; frequent magnetic crack-detection checks between operations to avoid wasting labour; modern boring methods for simplifying the problems of drilling deep holes; rough and finish grinding and honing, to ensure high surfaces finishes, of the order of 1 to 2 micro-inches, and extreme accuracy of size; the use of Hydrotel copying machines for intricate machining; multiple milling cutters to ensure accuracy of related dimensions; and improved jigging and tooling for obtaining hole-centre tolerances of the order of 0·0002 in. Mr. Dowty also cited the substitution of light alloy for steel in many components, made possible by the development of the hard-anodising process for providing wear-resistant sliding surfaces on light alloys (this process is described briefly in an article on page 18.—ED.).

Considering standardised equipment, higher performances had been obtained by increasing the operating pressures of hydraulic pumps and by speeding-up fuel pumps. The higher efficiencies obtained had called for the installation of high-precision machine tools, measuring and testing plant. The use of water-based fluids and of non-lubricating fuels had required intensive research on bearing surfaces, and good results had been obtained with surfaces impregnated with molybdenum sulphide. Sulphur-impregnated surfaces were now under development. To obtain satisfactory results from high-performance pumps and valves, a high standard of surface finish and of accuracy of form and dimension was required, with tolerances of the order of 0·0001 in. to 0·0002 in. Techniques had been developed to enable these standards to be maintained in production by semi-skilled labour.

The second paper on production problems, given by Mr. S. P. Woodley, dealt with the airframe. The trend in design was leading to a change-over from built-up sheet-metal construction to machined integrally-stiffened light-alloy skins, resulting in a stronger and lighter structure, with a considerable reduction in the number of parts and a consequent overall reduction in production time and tooling (although the machining costs were higher), but demanding a much greater capital cost than hitherto. In view of a possible switch-over to steel and titanium structures as aircraft speeds rose still higher, the production engineer had a serious problem in deciding how far this capital outlay was justified. Mr. Woodley suggested that the solution lay largely in the development and adaptation of existing machines.

FORGING AND MILLING

At present, large one-piece components were cut from solid billets. A great economy in time and material would be possible if large forging presses, of at least 35,000 lb. capacity, were available; and as a result of the better grain flow of the forging, the members thus produced would be more efficient. Such presses were costly—about £2¼ million—and, to be economical, would require to be used with progressive dies to produce "close-to-limit" forgings in order to save machining time.

Copy-machining, now used increasingly, could not at present be used for forming large components from forgings—such as fuselage frames and wing ribs—where three-dimensional machine control was required combined with axial control of the cutter head in two vertical planes. Such a machine was, however, under construction in the United States, using electronic tracers in conjunction with a steel template. Later, it was intended to control the machine by a computing mechanism fed with numerical information.

For skin milling, which required a different type of machine to produce the desired stiffeners, rebates, and relief pockets, routing machines, operating in conjunction with a roller conveyor platform, were being developed, in which the cutter heads were mounted on radial arms and the skin area being cut was held on a vacuum table. Templates were employed to guide the cutter heads. Such machines were comparatively inexpensive in relation to a skin-milling machine. For forming the wing-surface contours, several copying machines were now under development. The lecturer suggested that computor control, or control by an "electronic eye" direct from a drawing, would ultimately be used in place of a master form and tracers.

With the adoption of tough 100-ton steels, problems of cutting time and cutter life had arisen. The use of high-pressure oil jets or of carbon dioxide as a cutter coolant might increase the life and improve the surface finish obtained.

A fine surface finish was essential to avoid stress concentrations. Another possible development was the commercial application of the Sparkatron process of electrolytic machining, which had been developed on a small scale and by which the hardest materials could be machined. With the use of high-tensile steels, higher-powered rolls than those at present available in the aircraft industry (which were suitable for light-alloy sheets with a maximum thickness of 6 s.w.g.) would be required.

Although, in the United Kingdom, titanium was available on only a small scale, and its alloys were unobtainable, immediate research was necessary on its fabrication by machining, forming, forging, welding, etc., both experimentally and in production. Otherwise, when the material became more readily available, the industry would not be able to utilise it fully. With the machining of large billets and forgings of high-strength alloys, heat-treatment problems had become more severe, and techniques must be evolved to enable heating and quenching to be carried out without distortion ; e.g., by treating the component completely enclosed in a die.

SURFACE FINISH

In order to produce the high surface finish necessary on notch-sensitive light alloys, laborious polishing techniques had been replaced by " barrelling " or by the vapour-blast process. In the former process, which produced a surface finish better than 14 micro-inches, the components were rotated for several hours in a large rubber-lined cast-iron or welded drum containing limestone chippings, water, and a foaming agent. Large components were jigged during the process so that they could not mark each other. The process was entirely mechanical and required no operator. Neither of these processes was satisfactory for high-tensile steel, but possibly electrolytic polishing might provide the solution.

Among the points raised in the discussion which followed the first two sessions was the suggestion that electrical wiring might be simplified by introducing printed circuits, and that production could be facilitated if materials manufacturers could supply taper-rolled sheets and stringers, as had been employed in the Dassault Mystère aircraft in France. The wider applications of magnesium-zirconium alloys for secondary structures, suggested by one speaker, had been limited by the fact that most British aircraft firms were not equipped for hot-forming. The elimination of joints, it was suggested, would add considerably to installation difficulties and to the cost of spares and maintenance. Moreover, in considering the cost of integral construction, the man-hours absorbed in building costly presses and machine tools should be included.

For speeds of the order of Mach 3, the kinetic temperature rise would be such that alloy steels were the only possible solution. Experiments on the use of high-pressure cutting oils at the College of Aeronautics, when cutting steel to S.11 specification, had shown cutting-life increases ranging from 25 per cent. to 100 per cent. It appeared, however, to be generally agreed that the aircraft industry in the United Kingdom was not devoting enough effort to developing new production techniques and to training production engineers.

USER PROBLEMS

At the third session, on Saturday, on " User Problems Affecting the Industry," Mr. B. S. Shenstone gave the views of a commercial operator and Air Marshal Sir R. Owen Jones spoke for the services. Although the operating and servicing conditions of a commercial air line differ greatly from those of the Royal Air Force, it was noteworthy that both the speakers had certain points in common, probably the most vital of which was the question of deliveries on time.

The aircraft operator, Mr. Shenstone said, had to work to a schedule, and if that schedule were based on the expectation of promised deliveries of new aircraft which did not arrive on time, the results could be disastrous. This applied also to the delivery of spares, to the turn-round of aircraft from modification, and to the overhaul of equipment sent to the manufacturer. On the same subject, the Air Marshal said that re-equipment plans of the Royal Air Force were bound up closely with production, so that the provision of man-power, airfields, equipment and accommodation was geared to the forecast programme. If production was late, specially-trained personnel might have to remain idle or be dispersed, pilots might suffer a loss of morale and enthusiasm, and provision of spares for obsolescent aircraft could not always be arranged at short notice. The initial provision of the requisite maintenance spares was of great importance to the Royal Air Force, as were also test equipment and ground-handling gear. The increased thickness of skin plating and the new construction techniques, essential for high-speed aircraft, were difficult to repair ; the only solution was to carry more spares and facilities for rapid replacement.

" ORDERING FROM THE DRAWING BOARD "

Discussing modifications, the Air Marshal said that the recent practice of " ordering from the drawing board " had led to many more modifications, the need for which was not apparent until production and flying started. To accelerate development, the Royal Air Force now carried out intensive flying trials on the first deliveries, accumulating 1,000 hours' flying on eight aircraft in the shortest possible time, but much of the value was lost if the early deliveries were not complete aircraft. A new single-seat machine coming into service could have as much as 800 man-hours of modification work outstanding on delivery, all of which had to be done under the servicing conditions of the Royal Air Force. Such an initial tendency could easily develop into a permanent back log. Anticipating questions as to the necessity of modifications, the Air Marshal pointed out that they were the physical manifestation of new ideas and potentialities.

Both speakers said that the interchangeability of components was still not always satisfactory. This problem was of particular importance in commercial avaiation, on account of the long lives demanded of civil aircraft. Mr. Shenstone suggested a figure of 30,000 hours, which meant that components had to be removed and replaced hundreds of times. He suggested that interchangeability should be considered in designing the jigging, and that the manufacturers and air-line engineers should jointly tackle the problem.

In discussing the long life, free from dangerous fatigue, required for commercial aircraft, Mr. Shenstone said that he did not expect the manufacturer to produce an aircraft completely free from fatigue troubles, but the main structural parts must be designed so that, when fatigue started, it could be detected by normal inspection methods, without catastrophe and without fantastic cost. He thought that the production department, who knew far more than the designer about the physical attributes of the parts manufactured, could help in assessing the durability of unstressable detailed parts, which was too often discovered by the travelling public.

Consistency of performance of equipment was another quality which Mr. Shenstone found unsatisfactory, e.g., many components broke down before they attained their specified life between overhauls; and, on more than one aircraft, ailerons which were supposed to be identical were found to give different handling characteristics.

STANDARD OF FINISH

The standard of workmanship in British commercial aircraft, Mr. Shenstone considered, was not up to that of American aircraft. In particular, electrical wiring was poor, and he cited a recent case of an operator who bought new British transport aircraft and had to renew all the wiring before putting them into service. Mr. Shenstone also complained that the finish of British aircraft was unsatisfactory, and that the continued use of non-flush riveting, which rendered cleaning more difficult, made a bad impression on intending buyers. Sir Owen Jones also complained of poor quality riveting, and suggested that new riveting techniques were necessary to eliminate the number of loose and broken rivets that were now frequently found. He felt that current blind riveting methods were not effective for present-day loadings.

In the discussion following the two papers on users' problems, it was suggested that the conference had by-passed the principal problem —that of producing the right aircraft at the time it was needed. Twelve aircraft-years elapsed between the initiation of design and the time when a military aircraft would be released for service. It should be possible to shorten this period by starting production before it was fully proved. For commercial use, however, Mr. Shenstone could not accept an aircraft that had not been fully developed. It was suggested that the lower delay between design and production in the United States resulted from the fact that the U.S.A. could afford a larger " wastage " rate than in the United Kingdom, and could " flood " the project design office with manpower. Although this would be impracticable and wasteful in the United Kingdom, it was possible that delay resulted from an over-cautious attitude in deciding what was feasible.

In conclusion, Sir Frederick Handley Page, summing up the discussions, said that it was not true that the delay between initiating a design and the delivery of the first production machine was greater in the United Kingdom than in certain other countries ; a recent survey had shown very little difference. It was inevitable that, in an industry dealing with a rapidly changing technique and increasingly severe requirements, the necessity for modifications must arise. To avoid delays in production, the prime necessity was for the orders to be placed as soon as possible. The aircraft and its equipment must be integrated from the start of the design, and the production and service engineers should be consulted from the beginning.

When considering new forms of construction and the equipment necessary for them, consideration must be given to the need for rapid expansion in time of war. If production depended largely on the possession of capital equipment and expensive tooling, expansion would be delayed. There was also a limit to the application of highly skilled processes to production, since the capabilities of the human material available were limited. Referring to the problem of getting the right type of production engineer, he said that there was a tendency for the apprentice of ability to pass into the technical office rather than into the shops, since he was more easily able to assess his technical capacity than his capacity for leadership. For this reason, Sir Frederick thought that every engineer should serve his time in the shops and thus learn how to use the human " tools."

Book Reviews

PRACTICAL APPLICATIONS OF ELECTRONIC COMPUTERS

Faster than Thought. A Symposium on Digital Computing Machines. Edited by DR. B. V. BOWDEN. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.*2. (35*s.* net.)

Dr. Bowden has provided the general scientific reader with the first comprehensive guide to the machines popularly known as "electronic brains." Many people have tended to regard these inventions as near-human, while others have dismissed them as mere scientific toys. In fact, of course, electronic digital computers (to give them their proper name) are simply scientific instruments. They are immensely powerful aids to mathematical calculation, but their value depends entirely on the skill of the human beings using them.

Some of the important problems these machines have already solved are described, though it is obvious that many fields of application have hardly been touched. By drawing on the knowledge of engineers as well as mathematicians, the author has also been able to include a clear account of the basic problems of machine design, construction, and maintenance. The book is divided into three parts. The first is devoted to the general principles on which all digital computers are based. It gives an intriguing account of the history of computing, and describes the life and work of Charles Babbage, who envisaged the automatic computer more than a century ago. Although his analytical engine was never built, its design incorporated most of the logical features found on present-day machines, and in some respects it was even more ambitious. For the reader with some knowledge of electronics, there is an account of the circuits and components used in modern computers, together with much interesting information concerning machine performance and reliability. The author stresses the extreme care necessary in design and manufacture if a computer is to produce the right answer at the end of a million arithmetic operations. This section also includes a general account of programming, and describes the steps necessary in organising a mathematical problem for machine solution. Most computer laboratories issue programming handbooks for their own machines, and the reader is referred to these for fuller details of coding procedure.

The second part gives a description of the various machines working or under construction in this country. Designers are still trying out new ideas for making machines faster, cheaper, and more reliable, and the varying needs of different types of user have led to a great diversity of machine sizes and speeds. A few details are also included of the more important machines operating in the United States.

The third and largest section of the book is the one likely to be of most practical value to engineers. Here Dr. Bowden describes the various problems digital computers have already tackled, and suggests others for which they may be suitable. Among other examples he quotes problems in logic, ballistics, crystallography and structural engineering. The use of machines in commercial and census work is also discussed and it appears that while they may have a valuable part to play, different types of machine are needed from those developed for scientific calculations. For several problems detailed flow-sheets are included showing how the calculation is arranged for the machine, and the reader interested in particular fields is provided with many references to more specialist work. One chapter is concerned with the application of machines to games. Human beings may take comfort here, for the Manchester computer, at any rate, seems unlikely to win even a minor chess championship for many years to come. The final chapter describes the exploits of gifted human computers like Mr. W. Klein and Professor A. C. Aitken, and how machines have influenced our ideas on the processes which occur in the human brain. The layman often asks whether machines can think. The real problem is to decide whether human thought is anything more than the product of a highly flexible computer with a vast (though sometimes unreliable) storage system. Whatever the answer to this question, the author sees no possibility of the circuitry of any machine ever approaching the complexity of the human brain.

From such a collaboration of experts one would expect an authoritative book, and the engineer wondering whether his particular problem is suitable for automatic computation will find nearly all his questions answered. It is seldom, however, that one finds experts writing so entertainingly, or with such obvious enthusiasm for their work. One feels that all the contributors have found digital computers great fun, and Dr. Bowden's vast fund of computer stories and his flair for the apt quotation set his subject on a plane that will assuredly never be reached by an "electronic brain." Users of the Manchester computer will complain that Plate 6 is upside-down, but this hardly mars an otherwise excellently produced book.

The Year that Made the Day. *The British Broadcasting Corporation, London, W.*1. (6*s.*)

This book is an account of how the British Broadcasting Corporation planned and prepared the successful broadcasts on Coronation day. The approach is non-technical; the other, and perhaps more interesting, aspect has been dealt with in a paper read before a meeting of the Institution of Electrical Engineers on Thursday, December 3, 1953, an account of which appeared on page 775 of our 176th volume. There was, however, a good deal of "human" as well as technical interest in the arrangements and these are well brought out in this book. A tribute must be paid to those who were responsible for taking and selecting the excellent photographs which are reproduced. It is hardly too much to say that the broadcasts were the result of careful planning and excellent organisation. They were crowned with complete success on what may be fittingly described as the greatest day in the history of television.

British Standards

The following publications have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2 Park-street, London, W.1, at the price given after each title.

Unified Screw Threads (with Metric Equivalents). (12*s.* 6*d.*, post free.)

A revision of B.S. 1580, covering unified screw threads has been issued to replace a provisional specification published in 1949. The purpose of the revision is to take account of the criticisms submitted by industry following the experience gained in the manufacture and use of this relatively new screw thread. The thread sizes and pitches and the manufacturing limits laid down in the provisional specification have been fully confirmed; hence the revision, B.S. 1580 : 1953, demands no change in tool design. Particular attention has been given to the basic form or theoretical profile and the design forms, or the forms of internal and external thread in relation to which tolerances are assigned. The basic form has now been adopted by the International Organisation for Standardisation as the basic profile for an international screw thread. A new section is included dealing with threads which are to be plated, and the tables of limits and tolerances have been revised to show the sizes before and after plating. Although considerable endeavour has been made by representatives of the United Kingdom, Canada and the United States, it has not been possible to reach agreement on a range of standard diameters and pitches below ¼ in. diameter in the unified range. In an appendix to B.S. No. 1580, however, is now given a list of five sizes of small screws for use in the attachment of main assemblies to a larger unit, such as instruments to a panel. The Canadian and American representatives have agreed to recommend these sizes for similar purposes on their own products.

Dimensions of Fractional Horse-Power Motors. (2*s.* 6*d.*, post free.)

For many years there has been a specification for the performance of fractional horse-power motors (B.S. 170), but there has been no dimensional standardisation in the United Kingdom. This lack of standardisation has now been rectified by the publication of B.S. 2048, which establishes standard dimensions for two frame sizes of fractional horse-power motors. These frame sizes are such as will normally cover the following horse-powers at four-pole speeds, 50 c/s. frequency, in drip-proof single-phase capacitor-type continuously-rated motors:—frame 56: ¼ to ½ h.p., and frame 66: ½ to ¾ h.p. The dimensions specified are those necessary to ensure that motors of different makes, but complying with the specification, will be mechanically interchangeable for all normal applications, when mounted on the driven machines. The new standard is applicable to D.C. motors and single-phase and poly-phase A.C. motors having enclosures of the protected, drip-proof and totally-enclosed types.

TRADE PUBLICATIONS

Tools and Supplies. Buck & Hickman, Ltd., 2-8, Whitechapel-road, London, E.1, have sent us their General Catalogue of Small Tools and Supplies. Not including variations in size, about 10,000 different tools or pieces of equipment are described in the 1,270 pages contained in the catalogue. The requirements of every type of workshop or yard appear to be catered for, ranging from abrasive cloths to zinc stencils and from B.A. screws to complete forges and cranes.

Data Book on Resistance Welding. A pocket book recently published by Sciaky Electric Welding Machines, Ltd., Farnham-road, Slough, contains illustrations showing the four basic types of resistance welding, as well as a great deal of technical information on this process, which should be of use to engineers, designers and foremen.

Miniature Pneumatic Valves. A range of miniature valves for pneumatic control are described in a leaflet issued by Lang Pneumatic, Ltd., Wolverhampton. Three and four-way valves operated by solenoid, air, cam, foot and other mechanisms are illustrated, together with ¼-in. B.S.P. fittings and small cylinders designed for use in conjunction with the valves.

Turbo-Exhausters and Blowers. The Sturtevant Engineering Co., Ltd., Southern House, Cannon-street, London, E.C.4, have published a leaflet, No. 5602, dealing with turbo-exhausters and blowers for industrial service, designed for applications requiring a vacuum of 2 to 10 in. of mercury, or an air pressure from 1 to 6 lb. per square inch. Charts show the range of volumes, and a list of some of the many applications is given.

BOOKS RECEIVED

Static Electrification. A Symposium held at the Institute of Physics in London on March 25, 26 and 27, 1953. *The Institute of Physics*, 47, *Belgrave-square London, S.W.*1. [25*s.*]

European, Foundries and Productivity. *Organisation for European Economic Co-operation*, 2, *Rue André Pascal, Paris* (16*e*) [700 francs]; and *H.M. Stationery Office, Kingsway, London, W.C.*2. [14*s.*]

The Year that Made the Day. How the B.B.C. Planned and Prepared the Coronation Day Broadcasts. *British Broadcasting Corporation, Broadcasting House, London, W.*1. [6*s.*] (See short review on this page)

Exports in a Buyer's Market. Report of the F.B.I. Export Sales Conference, Buxton, October 30 to November 1, 1953. *Federation of British Industries*, 21, *Tothill-street, London, S.W.*1. [3*s.* 6*d.*]

The Control of Quality in the Production of Wrought Non-Ferrous Metals and Alloys. I. The Control of Quality in Melting and Casting. A Symposium held in London on March 25, 1953. *The Institute of Metals*, 4, *Grosvenor-gardens, London, S.W.*1. [15*s.*]

The Engineering Outlook—1

RETROSPECT AND PROSPECT

I—MARKETS AND FINANCE

THE immediate outlook for many of the engineering industries is rather an anxious one. For some time, the rate at which orders have been coming in has been below that of deliveries. In shipbuilding, very few orders indeed have been received during the past year, and several have been cancelled. This is the extreme case, but other basic engineering industries, like machine tools, heavy commercial vehicles and textile machinery, are similarly affected. There are some exceptions in those engineering industries which manufacture equipment for the iron and steel industry, where the five-year expansion programme is under way, or make contractors' plant or mechanical handling equipment. Those industries which make hardware and consumer goods are still experiencing a very buoyant demand on the home market, but many manufacturers are uneasy about future prospects. Although, therefore, the index of engineering production in 1953 recovered from the low levels of the second and third quarters of 1952, no one is likely to find in that any cause for self-congratulation. The recovery was followed by another fall in the index of industrial production for most branches of engineering, as the graphs at the top of the opposite page show (based on an index of 100 in 1948).

It is rather ominous that the rise in production has been accompanied by a shrinking of the engineering labour force. This may be evidence of increased productivity and higher efficiency, but it is also evidence of defective demand, since employees displaced, sometimes by more efficient methods, but usually as a result of the reduction in armament contracts, are not being reabsorbed. Re-armament now accounts for a very small part of the total engineering activity, and by the middle of 1954 most of the outstanding orders will have been completed.

Another disturbing feature is the extent to which production is being sustained by home demand. Exports of the British metal-using industries fell substantially in 1953, as shown in Table I and by the graphs at the bottom of the opposite page (based on an index of 100 in 1950). Reduced prosperity in some of the major British markets in the Commonwealth, following the weakening of raw material prices, has been partly responsible. Conditions in some, at least, of these markets have improved sufficiently to permit a considerable relaxation of import restrictions, but this will not automatically produce an increase in the total of British exports.

Much ground has been lost in the past two years to foreign competitors, particularly the Germans, and unless British manufacturers can sell as cheaply as these rivals and offer credit terms at least as favourable, their export prospects are poor. Failure to maintain competitive prices will have repercussions far beyond the confines of the engineering industry, since it is upon engineering exports, which now account for 41 per cent. of total British exports, that the Treasury must rely increasingly to maintain a balance in the payments account. Low costs are thus essential and it is vital that this should be taken into account in negotiations for wage increases. The Amalgamated Engineering Union ignored it completely when they held their recent 24-hour strike in favour of a 15 per cent. rise in wages; a rise which would add £125 millions per annum to engineering costs. So far as employers are concerned, no doubt there is room for greater efficiency, both in sales and production methods. There is, however, little evidence as yet that investment on plant and machinery is increasing, despite improved credit facilities.

NEED FOR EXPORTS

The national income of the United Kingdom in 1953 was somewhat higher than in 1952—perhaps by as much as £500 millions—but this has been due largely to an improvement in the terms of trade. Less had to be paid for the raw materials imported from abroad, and consequently it was possible to devote more resources at home both to the purchase of consumer goods and to housing, factory buildings, industrial equipment and capital investment generally. This prosperity, however, has rested on very insecure foundations; the surplus in the balance of payments at the end of June, 1953, had fallen to £81 millions, and this included aid from the United States of £55 millions. It might be justifiable to work so close to the margin if the United Kingdom had large reserves of foreign exchange; but while, as at present, the reserves are totally inadequate, financial policy must be directed towards obtaining a substantial surplus in the foreign account. Some of the resources which are being used up at present to raise the standard of living or for increasing less essential capital formation at home must be devoted, therefore, to improving the balance of trade. The opposite tendency is much in evidence. Unable to sell their products overseas, manufacturers have been looking increasingly to the home market as the answer to their problems; and since the very existence of a healthy home market depends upon the maintenance of a high volume of exports, this policy must ultimately defeat itself. Its reversal will require all the energies and ingenuity of the engineering manufacturers in 1954.

GERMAN EXPORTS INCREASE

The full difficulty of the task can be appreciated only by examining some recent export trends. Until 1951, the main Commonwealth countries—Australia, New Zealand, South Africa, India and Pakistan—took nearly one-third of the total British exports; in 1953, they took substantially less than one-quarter. Fortunately, British exporters, forced to turn their attention elsewhere, were able to expand their exports to the United States, Canada and Western Europe. In these markets, however, they are exposed to the full force of foreign competition, which, even within the Commonwealth, has lately become something to be reckoned with. The distribution of British engineering exports is shown in Table II, below.

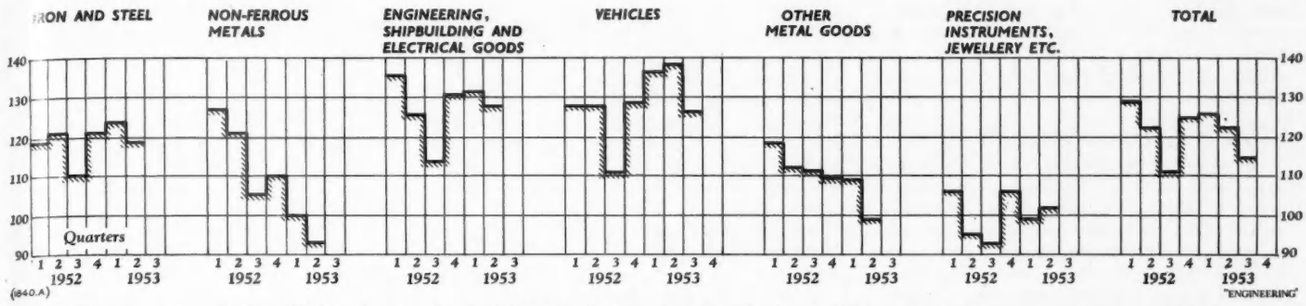
In a study of engineering exports by the British Engineers' Association, it is shown that, while German engineering exports rose by 98 per cent. between 1950 and 1952, British engineering exports increased by only 14 per cent. The British performance, moreover, was considerably worse than that of the United States, France and Sweden, whose engineering exports increased by 28, 45 and 33 per cent., respectively. The comparison is not quite so unfavourable for the British engineering industry, however, when the geographical orientation of the exports of the other countries is examined. The bulk of the German, French and Swedish exports has been directed to other Western European countries, and much of the remainder to Central and South America, which accounted for the greater part of the exports of the United States. Since 1951, the Western European markets have been comparatively strong, while the South American markets have contracted rather less than the sterling markets, so that British exporters have been in a relatively weak position. The character of British engineering exports, moreover, has not helped. Whereas motor vehicles have accounted for only about 14 per cent. of the German engineering exports, they accounted for 29 per cent. of the British exports in 1952. In 1953, motor-vehicle exports were among the most

TABLE I. UNITED KINGDOM: VALUE OF EXPORTS OF METAL MANUFACTURES. (£ MILLIONS.)

	1938	1951	1952	1952				1953		
				1st Qr.	2nd Qr.	3rd Qr.	4th Qr.	1st Qr.	2nd Qr.	3rd Qr.
Iron and steel, and manufactures thereof	44·6	159·6	191·6	47·7	48·5	41·8	53·6	50·7	47·8	46·9
Non-ferrous metals, and manufactures thereof	12·3	70·5	82·4	22·5	20·8	17·3	21·8	22·1	21·7	23·1
Cutlery, implements, instruments, etc.	9·0	62·7	63·6	19·0	16·3	14·2	14·1	14·2	14·1	14·3
Electrical goods and apparatus	13·4	96·6	109·6	30·2	27·3	25·5	26·7	27·2	25·8	24·2
Machinery	57·9	363·1	421·7	112·9	105·9	97·6	105·3	102·2	103·1	95·3
Vehicles	44·6	480·3	479·2	138·9	123·1	106·4	110·8	110·2	120·6	114·7

TABLE II. UNITED KINGDOM: EXPORTS OF PRODUCTS OF THE ENGINEERING INDUSTRY TO SELECTED AREAS. (Monthly Averages, £1,000, January to September.)

	1952			1953		
	Electrical Goods	Machinery	Vehicles	Electrical Goods	Machinery	Vehicles
United States	97	751	1,546	117	905	1,860
Canada	253	1,378	1,593	305	1,597	2,654
Other American account countries	229	799	865	157	942	1,666
Non-dollar Western Hemisphere countries	403	2,285	2,188	156	1,020	1,175
Australia	797	4,070	4,988	619	3,413	3,842
Union of South Africa	832	2,887	1,676	891	3,189	2,036
Colonies	1,356	3,626	5,132	1,578	4,455	4,855
Non-sterling O.E.E.C. countries	1,650	7,842	10,744	1,562	7,435	7,128
O.E.E.C. possessions	90	828	951	70	785	720
Irish Republic and Iceland	311	959	836	218	929	768
Eastern Europe	233	1,011	1,416	235	678	477



These diagrams show Industrial Production in the United Kingdom for the whole of 1952 and for those Quarters of 1953 for which figures are available. In general, the Recovery in 1953 from the low levels of 1952 was followed by another fall.

severely hit, and their share of the British engineering exports fell to 26 per cent.

No country has achieved any considerable increase in exports of engineering products in 1953. German exports will probably prove about as high as in 1952, despite a fall in shipments to South America ; this was the result of the deliberate policy of the German banking system, which has restricted credits where the risks have been considered too great. They are gaining in the Commonwealth, and there is cause for concern in the frequent reports received in recent months of orders lost by British companies to German manufacturers in India, Pakistan, South Africa and elsewhere. A recent startling example was the Indian award of a contract for a large number of locomotives and rolling stock to German and Continental manufacturers, whose prices were substantially below the British. Other important contracts obtained by German engineers include a Pakistan steel mill, a South African synthetic petrol plant, and a bridge over the Bosphorus.

COUNTERING FOREIGN COMPETITION

It may be that British manufacturers can look forward to an increase in exports to Australia and New Zealand in 1954 ; in other parts of the Commonwealth, however, they may well be faced with a further decline, because the incomes of many producers of raw materials are still declining. In India, the five-year development plan has suffered a setback, and in Pakistan also progress has been interrupted. In any case, the establishment of manufacturing industries in these countries must bring about a reduction in many classes of their engineering imports. A striking example of how the growth of local production and currency difficulties have combined to reduce imports of engineering goods is that of Diesel engines. These are urgently needed for the large-scale agricultural and hydro-electric projects. Since 1946, the output by the six Indian manufacturers has about trebled, and by 1955 is expected to reach 55,000 units. Even this, however, is insufficient to meet home requirements, and the fact that Indian imports of British Diesel engines have had to be cut from £3·2 millions for the period January to October, 1952, to £323,000 for the corresponding period of 1953 is an indication of the gravity of the situation.

If British manufacturers are to increase their exports in 1954, it is clear that they will have to rely increasingly on non-Commonwealth markets and that foreign competition, within and without the Sterling Area, may be expected to grow more intense. Some are already attributing the success of the foreigner to unfair practices. It is alleged that absurdly low prices are often quoted to gain an entry into a market, or simply to keep factories employed ; and that, in some cases, foreign manufacturers have been enjoying the benefit of both concealed and unconcealed subsidies. These allegations are in large part true, and British production costs, where it is at all possible to make a comparison, appear to be little if any higher than those of their competitors—including the Japanese, whose low labour costs in recent years have been offset by the high prices paid for steel.

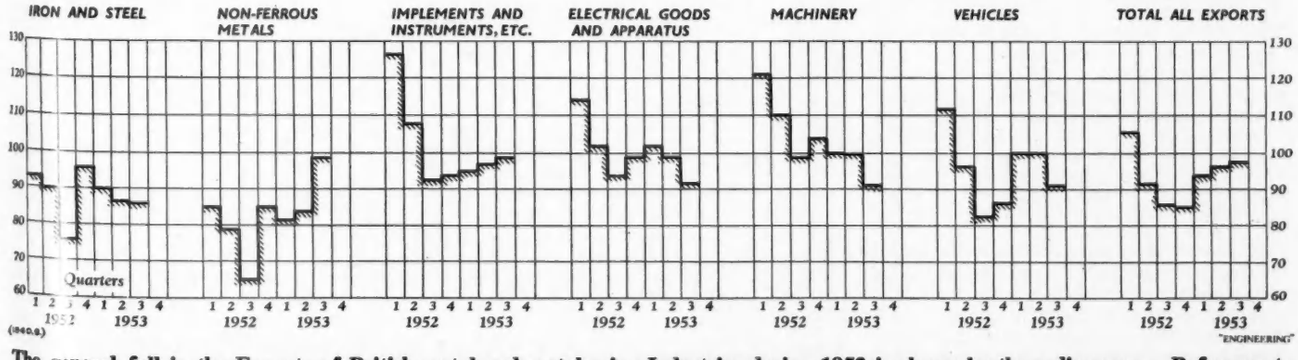
One of the main advantages enjoyed by foreign competitors, and by the Germans in particular, is that often they can offer very extended credit terms ; German companies are said to be able to offer credits up to seven years. Their export credit bank can directly offer four-year terms, and, since the credits need not begin until one year after the contract is signed, a five-year credit can be given by arranging for a commercial bank to finance the initial year. It is possible, moreover, to extend credits far beyond this, by securing from the banks, long before the contract is signed, a promise of rediscount facilities. Some credits of more than ten years are being granted, as in the case of the Pakistan steel mill. One of the most recent examples of the German determination to develop exports is the granting of industrial credits to the value of £18 millions to Greece. The credits range from five to eight years in duration, and will be used to finance shipbuilding and ship-repairing installations, sugar factories, a nickel plant, and possibly a chemical and steel works.

CREDIT FOR FINANCING EXPORTS

In the United Kingdom, complaints have long been heard by manufacturers about their inability to obtain credit to finance their exports ; and, in fact, in face of the crisis in the balance of payments, it has been the Government's policy, through the Foreign Exchange Control Committee, to restrict the length of credit granted to foreign importers. This was an emergency policy which no one pretended to be sound, and it was largely reversed by the Chancellor of the Exchequer, Mr. R. A. Butler, last April. The banks are now granting overdrafts more freely to cover at least the finance of medium-term contracts, and the Export Credits Guarantees Department has shown a greater willingness to cover risks in many markets.

The Department has been charged with being over-discriminatory in some markets, particularly South America, but cover is rarely refused without ample justification. Even the Germans are cutting down their risk commitments in those markets, and there now seems to be some doubt whether the Volkswagen and Daimler-Benz companies, who have been conducting negotiations for the building of motor vehicles in Brazil, will carry their plans through.

Mr. Butler stated in April that the problem of finance for British exports was really one of making known the facilities that already existed ; complaints about the inadequacy of machinery were largely unjustified. This is true, at least in part, particularly so far as shorter credit is concerned, since it seems that the bill of exchange, one of the simplest mediums for this type of credit, is too little used. On the other hand, there can be no doubt that credits for capital goods as long as those extended by their German competitors are not available to British manufacturers. The wisdom of the Germans in



The general fall in the Exports of British metal and metal-using Industries during 1953 is shown by these diagrams. Reference to the diagrams on this page is made at the beginning of this, the first, Article in the "Engineering Outlook" Series.

extending such protracted credit is open to question, but the fact remains that, while they continue to do so, they are likely to obtain orders which otherwise might be placed in the United Kingdom.

HELP FOR THE SMALLER FIRMS

A welcome development, which will help manufacturers in the engineering industry to solve the problem of export finance, is the formation of the Manufacturers' Export Finance Company. This development, covering the whole of engineering, follows the lead set by the aircraft industry in September, when the Air Finance Company was set up. The scheme for the engineering industry will be concerned solely with capital goods, and is designed to help the smaller companies in the industry. The new company will have a capital of £250,000 and one of the joint-stock banks has agreed to provide loan facilities up to an initial amount of £2 millions. Although inadequate for the global needs of British industry, this promises a more realistic approach to the problem of export credits.

British exporters are not entirely without protection against unfair trading practices. International action has been undertaken already to curb them. At the instigation of the Federation of British Industries, the Council of European Industrial Federations have put a recommendation to their various Governments that there should be no increases in the provision of artificial incentives for an initial period of three months. This is no more than a truce, but it will serve a useful purpose if, while it lasts, the whole matter can be thrashed out by such a body as the Organisation for European Economic Co-operation, and some agreement obtained on the limitation of export subsidies and on the reduction or elimination of export and home price differentials. Some British practices will come in for as close a scrutiny as the Continental; for example, the United Kingdom may find it hard to justify the differentially high export prices charged for coal.

On the whole, international action in this direction will benefit the United Kingdom, but it must not be assumed that British salvation will necessarily be found in progress towards freer or "fairer" trade. Certainly, the General Agreement on Tariffs and Trade (G.A.T.T.), which does not permit members of the Commonwealth to raise import duties against non-Commonwealth countries without also raising them against other members of the Commonwealth, has not assisted the flow of inter-Commonwealth trade. At the 1953 session of the conference, only limited concessions were granted to the United Kingdom, under which, in certain conditions, permission was granted to raise preferential tariffs on some commodities. At the same time, against opposition from the United Kingdom and other Commonwealth countries, Japan was admitted to associate membership of G.A.A.T. for a provisional period ending in June, 1955. Should Japanese competition with cut-price goods again become a serious factor in world trade, therefore, the Commonwealth can no longer seek a remedy by raising tariffs.

QUICK DELIVERY

One factor which should help some categories of British exports is increasing ability to offer delivery as quickly as their competitors. Now that defence commitments have been reduced, material shortages largely eliminated, and order books brought to manageable proportions, there can be little excuse for failing to attend promptly to the customer's requirements. Unfortunately, there is much truth in the charge that many British exporters still do not do enough towards adapting their product and their selling effort to overseas requirements. For every British representative who is studying conditions and building up goodwill in foreign markets there are two or three Germans. Trade literature is presented all too seldom in the language of the market to which it is directed, or in a form which appeals to potential buyers, and the foreigner must often be driven to despair by the complicated conversions that he is called upon to perform on British weights and measures. Where quotations are requested, he prefers these to be given in terms of his own currency, with delivery to his own factory, but the British exporter does not invariably give him this information. In some markets, success or failure may depend on making minor adjustments to the product, and in others it may be necessary to adapt marketing methods to local conditions. In some, for example, it will be found necessary to offer comparatively high discounts to make a product acceptable to distributors, although the same product, carrying lower discounts, might undersell competing products.

INVESTMENT FOR EXPORT

A successful export campaign begins, of course, on the factory floor, and this means ensuring that the tools for the job are adequate. It has been clear for some years, however, that the rate of private industrial investment has been barely adequate to keep existing capital intact. This was inevitable while investment had to be curtailed to meet the competing needs of exports and the defence programme; when, however, as in 1952, both exports and defence production were curtailed, the way should have been clear for substantially increased investment in plant and equipment. Unfortunately, much of the increase in the national income was dissipated in current consumption; of such extra resources as were devoted to investment a large part went to housing, and of the remainder most seems to have gone to public authorities and corporations.

An examination of recent trends brings out some interesting conclusions. The Treasury, in their *Bulletin for Industry* for October, produced evidence to show that the volume of industrial investment in 1952, despite a fall from the 1951 level, was 20 per cent. higher in real terms than in 1948. The total fixed capital formation, valued at 1948 prices, rose from £1,393 millions in 1948 to £1,551 millions in 1952. Investment in plant and machinery increased from £489 millions in 1948 to £617 millions in 1951, but had fallen off to £596 millions in 1952, when it was still about 30 per cent. higher than in 1948. An analysis of investment by industry is given for the years 1948 to 1951, but no attempt is made to show the trend of investment in the various sectors. Of the total investment in manufacturing industry of £1,687 millions over the four-year period, £222 millions were spent on engineering, shipbuilding and electrical goods, £215 millions on the food and drink industries, £199 millions on chemicals, £192 millions on textiles, £179 millions on steel, and £111 millions on vehicles.

A study of the White Paper on *National Income and Expenditure for* 1952 gives a rather less favourable picture. From these returns, it appears that the fixed capital formation in the private sector of the economy rose from £773 millions in 1949 to £926 millions in 1952, or by 20 per cent. Prices, however, fell by about 30 per cent. over the period, so that the real investment in the private sector must have been substantially below the 1949 level. *Per contra*, the value of fixed investment in the public sector, which includes central Government, local authorities and public corporations, rose by about 48 per cent., from £761 millions in 1949 to £1,128 millions in 1952. Allowing for the rise in prices, real investment seems to have been about 12 per cent. higher.

GOVERNMENT MONETARY POLICY

Inadequate investment in the private sector and in private manufacturing industry in particular is not necessarily due to lack of enterprise; Government monetary policy must take some of the blame, at least. The public sector has found no difficulty in finding finance for defence and an expanded house-building programme, though its own saving has been quite inadequate for the purpose. Including defence aid, the funds available to the public sector from its own sources for investment fell from £1,026 millions in 1949 (which was £265 millions surplus to requirements) to £675 millions in 1952 (which was £453 millions short of requirements). Therefore, the extra finance had to come from the private sector, and was found, in fact, largely out of finance which otherwise would have been available to the private sector for its own investment. Increased interest rates and a policy of credit restriction reduced the total of bank advances by £201 millions without requiring the creation of much new money. Compared with the rest of manufacturing industry, the engineering industry has been fortunate in the matter of advances; between November, 1951, and November, 1952, engineering bank finance increased from £126·7 millions to £157·3 millions. This may have been largely due, however, to the increased finance obtained by companies on defence production, since it had fallen back to £147·3 millions by August, 1953.

During 1953, it was the declared intention of Government monetary policy that investment in private manufacturing industry should increase; thus, initial allowances were partly restored to rates of 10 per cent. on industrial buildings and 20 per cent. for plant and machinery, and the excess profits levy is to be repealed from January 1, 1954. Taxation reliefs in the "incentive budget" were designed "to improve our competitive efficiency, to provide incentives for greater effort and to encourage private saving." The results have been disappointing, however, and the blame must attach squarely to private industry. Despite the ready availability of bank finance, advances fell by £59 millions between August, 1952, and August, 1953, to £1,788 millions. The failure of industry to invest is due partly to an understandable unwillingness to replenish stocks while the future trend of raw material prices is uncertain, and a further fall is perhaps more probable than a rise. Nevertheless, it is clear that fixed investment has failed to rise, which seems to indicate that, when prospects for profits are considered to be poor, industry still tends too readily to take the negative course of retrenchment. Large companies are just as bad offenders as small. Too many have given instructions that, for the present, capital schemes shall be suspended or reduced.

Uncertainty is the keynote in the situation which faces the engineering industry to-day. The unpredictability of markets is not in itself of great consequence, but it would be most serious if the uncertainty affected the morale of British industry. Resolute optimism, enterprise and hard work are, after all, the only recipe for increasing sales and defeating foreign competition.

To be Continued

Succeeding articles will complete the general review started in this article, and then examine the commercial prospects of the principal branches of the engineering industry. Further information on industrial production is given in a "Weekly Survey" note in this issue.

BUCKLING AND STABILITY

NEW UNDERSTANDING OF THE BEHAVIOUR OF COLUMNS

THE failing load of a column, considered as part of a loaded structure, rather than as a hypothetical unit artificially compressed, depends on the rate of loading, the elasticity of the structure through which load is applied to the column, and the creep characteristics of the compressed material. These were the chief points made by Professor N. J. Hoff in the Wilbur Wright Memorial Lecture which he delivered to the Royal Aeronautical Society.* They are points of practical significance. Professor Hoff, who is Head of the Department of Aeronautical Engineering and Applied Mechanics at the Polytechnic Institute of Brooklyn, described investigations he has carried out – investigations sponsored by the Office of Naval Research of the U.S. Navy – and reviewed historical and contemporary knowledge of the subject generally. Though he was addressing aeronautical engineers, his Lecture contained much of value to other branches of engineering.

Quoting Vetruvius, he recalled the primitive analogy between the proportions of a column and those of the human figure, namely, height and diameter of the column, and height and foot-length of the human figure, which gave a ratio of 6 to 1 for the masculine column and 8 to 1 for the more elegant feminine one. It was to rules such as these that architects had worked for fifty centuries, for it was only 209 years ago that Euler (1744), developing a hint given him by Daniel Bernoulli, enunciated the classical theorem which was to become the basis of all subsequent developments in the theory of elastic stability.

But such was the simplicity and elegance of Euler's contribution that it was for too long regarded not as a starting point but as a system, and although architects and engineers soon found that the simple Euler formula, applied out of context, predicted unsafe loads for most of the columns actually used in building construction, no significant theoretical advance was made for nearly 150 years.

Some sixty years ago, Considère (1889) and Engesser (1889), working independently, explained the anomalous behaviour of short columns by distinguishing between the apparent elastic moduli of the outer and inner fibres, which correspond to the tension and compression areas in flexure. Their important contributions to stability theory " did not attract the attention of the engineering world," and no mention of their work appeared in the leading textbooks of the next two or three decades, such as Bach's *Elastizität und Festigkeit*, Morley's *Strength of Materials*, and the first six editions of Johnson, Bryan and Turneaure's *Modern Framed Structures*. Just over forty years ago, von Karman (1910) took Engesser's work a stage further, and in 1912 the Engesser-von Karman formula was re-derived independently by Sir Richard Southwell. Further contributions to the theory of short column buckling had since been made, particularly perhaps during the past ten years by F. R. Shanley.

Continuing his survey, Professor Hoff referred to " greater deviations from the behaviour predicted by the classical theory than that observed with the short column : the thin-walled circular cylindrical shell collapses catastrophically under a load which amounts to only one-third of the classical limit of stability ; the simply-supported flat plate can be subjected to loads exceeding the theoretical stability limit by a factor of ten or more if it is thin ; in a very rapid test the ordinary column can support a multiple of the critical load ; and an aluminium-alloy column maintained at a uniform temperature of 500 deg. F. will collapse, with a snap, under any compressive load, however small, if the test is continued long enough." The importance of dynamic effects was emphasised by the practical illustration that it would hardly be possible to drive a nail with a hammer if columns could not support axial compressive loads considerably in excess of the critical values when the loading was applied only for a short time.

* *Proc. Roy. Aero. Soc.*, vol. 58 (1954).

ANOMALIES IN SHORT-COLUMN THEORY

Professor Hoff's investigations had therefore been directed to the clearing up of outstanding anomalies in short-column theory and to consideration of the effects of rapid load application and of creep.

One of the outstanding problems of the short column had been the difficulty of predicting the loads at which failure occurred in a testing machine. Attacking this problem experimentally in the first place, Professor Hoff had recorded the time history of the loading head, of the axial compression in the column, and of the strain on the concave and convex sides of the middle of the column. Typical oscillographic traces of these four variables, with the two strains adjusted to different datum levels, are reproduced in Figs. 1 and 2, which show the very different behaviour of a long and a short column under the same test conditions.

For the long column, Fig. 1 " reveals that all four traces are straight lines until the buckling load is reached. At that moment a break can be observed in the lines, and from there on the strain on the concave side of the column increases at a higher rate and that on the convex side at a lower rate than before. The compressive load remains constant, and the loading-head velocity increases. Except for the last item, all the variations recorded are in good agreement with expectation based on the Euler buckling theory. The increase in the loading-head velocity is mainly a consequence of the elasticity of the testing machine. Under a constant load the pumps must furnish only enough fluid to take care of the increased volume corresponding to the displacement of the loading head, while before the Euler load is reached they also have to fill the additional space created by the elastic expansion of the pipes and containers under the increasing oil pressure."

For the short column, Fig. 2 showed that "the behaviour of the column is radically different. When the buckling load is reached, violent changes take place in all the quantities measured. The column snaps from its slightly deflected position into a highly deflected one with an audible thud. Records taken at a higher camera speed have shown that, on the average, the snap takes about one hundredth of a second."

Discussing the experimental results and the possibility of a theoretical explanation, Professor Hoff continued :—" One of the objectives in developing a dynamic theory of the buckling process of short columns was the explanation of the snap action. In 34 tests performed in the first series of experiments described in previous communications,* every short column snapped through and every long column failed gradually. It was not unreasonable to assume, therefore, that the violent changes taking place at buckling were a consequence of the non-linearity of the stress-strain relationship beyond the elastic limit. Nevertheless, several attempts to obtain the jump theoretically through introduction of a non-linear stress-strain law failed completely. It appeared from the calculations that the relief in compression accompanying the transverse deflections was so great that it effectively stopped any incipient sudden lateral motion."

ELASTICITY IN THE TESTING MACHINE

" This was found to be true when the displacement of the loading head was prescribed. The remedy for the situation was the assumption of some elasticity in the testing machine itself; this elasticity permitted the loading head to follow the downward movement of the column without a substantial loss in the compressive force when the column deflected laterally. When this

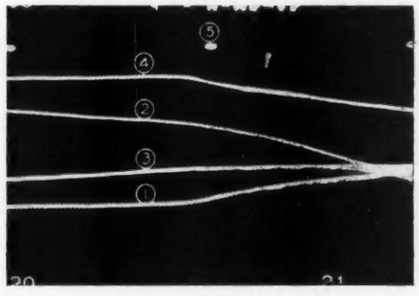


Fig. 1 Oscillogram of Test on a Slender Column in a Hydraulic Machine

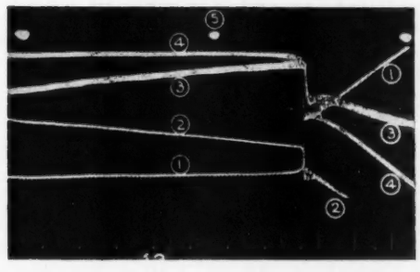


Fig. 2 Oscillogram of Test on a Short Column in a Hydraulic Machine

These two oscillograms illustrate the difference in the behaviour of slender and short columns on buckling. The violent changes which occur with short columns – known as snap-through – are considered to be due in part to the elasticity of the testing machine. The traces are : (1) *strain on concave side ;* (2) *head displacement ;* (3) *axial force in column ; and* (4) *strain on convex side. A time mark is shown at* (5). *The initial values of the strains are equal, but they are projected apart for the sake of clarity.*

* N. J. Hoff, S. V. Nardo and Burton Erickson, "An Experimental Investigation of the Process of Buckling of Columns"; P.I.B.A.L. Report No. 170, Brooklyn, N.Y., 1950; and *Proc. Soc. Exp. Stress Analysis*, Vol. 9, No. 1, page 201 (1951).

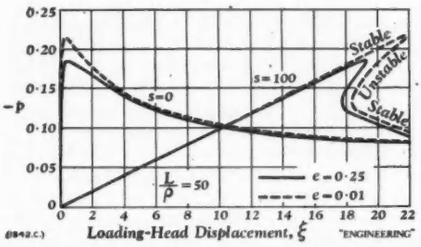


Fig. 3 Connection between the Load and Loading-Head Displacement (Static Solution, Non-Linear Column)
s **denotes flexibility of testing machine**
e **is a non-dimensional eccentricity parameter**

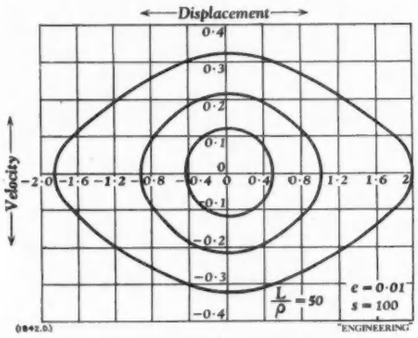


Fig. 4 Phase-Plane Diagram for $\xi = 18$

idea was introduced in the theory, the jump phenomenon was obtained. The pre-requisites for the snap-through (or jump) process are, therefore, a non-linear stress-strain relationship and an elastic testing machine. If either feature is missing, buckling occurs gradually." Full details of this theory, in connection with which Professor Hoff acknowledges a contribution made by one of his assistants, Professor F. V. Pohle, are given in an appendix to the published report of the lecture.

The success of the theory in interpreting the effect of the flexibility of the testing machine is clearly shown by the calculated curves reproduced in Fig. 3, in which $s = 0$ defines the perfectly rigid testing machine and $s = 100$ an ideal elastic one. The ordinate represents compressive load, and the abscissa displacement of the testing-machine head. Curves are plotted for two different values of the eccentricity of the loading axis, represented by the non-dimensional parameter *e*. "This diagram can be regarded as the history of the changes in the axial compressive force, *p*, in the column during a very slow loading process. When *c*, the loading-head velocity, is constant, ξ represents the time as well as the displacement of the loading head. Slow loading must be stipulated because the inertia forces were neglected in the analysis. The curves pertaining to the perfectly rigid testing machine ($s = 0$) do not present any unusual features; they show a drop in load after the maximum value is reached, as can be expected with columns buckling above the elastic limit of their material. . . . The entirely novel feature of Fig. 3 is that the curves corresponding to the elastic testing machine ($s = 100$) are triple valued in *p* over a considerable range of ξ."

"This fact changes significantly the behaviour of the column in the testing machine. As the loading head descends, the load increases approximately linearly at the beginning of the test. The deviations from linearity increase when the maximum load is approached, but they are not large because the greater portion of the end displacement can be attributed to the elastic deformation of the testing machine, which takes place in a linear fashion in accordance with the assumptions made."

"Immediately after the maximum load is reached, the curve turns back; this reversed curve does not correspond to any real loading process because it can be followed only if the testing machine is reversed. If this is not done and the loading head continues to descend at a uniform rate, no points of equilibrium follow in a continuous manner. Equilibrium at further increased ξ values is possible only at significantly lower values of the load *p* which correspond to materially increased lateral deflections at the middle of the column. Consequently, the column must jump from the small-deflection position into the large-deflection position, and during this snap-through process it must pass through positions in which static equilibrium is not possible. The resultant force in these positions does not vanish, but causes accelerations or decelerations in agreement with Newton's law."

Having established theoretically the connection between testing-machine elasticity and jump, or snap-through, at the buckling load, Professor Hoff obtained a quantitative solution by using the phase-plane method of analysis recently applied to non-linear columns in a P.I.B. Thesis.* Phase-plane diagrams, connecting the lateral displacement of the mid-point of the column and its velocity, were constructed for three different compressed lengths as the buckling load was approached. These diagrams, which are plotted non-dimensionally, are reproduced here as Figs. 4, 5 and 6, for compressed lengths of 18, 19, and 21·89, respectively, the last being "very close to the buckling load."

Fig. 4 indicates that, in this state of compression, the column is stable for all values of the amplitude; but at a slightly higher stage of compression. Fig. 5 shows that the column is only stable for small values of the amplitude, and that it can take up buckled positions on one side or other of the axis if the disturbance exceeds the critical values, which are slightly different on either side, due to the initial eccentricity *e*. In Fig. 6, the axially stable region of Fig. 5 is reduced to dimensions too small to be plotted on the diagram, and the alternative fully buckled deflections have modular values of between 6 and 8.

From the lateral deflection immediately after buckling, computed in this way, Hoff found that "the time necessary for the column to cover the distance from the starting point to the position of equilibrium at large deflections was 0·0015 sec." This was in good agreement with the time estimated from oscillograph records, and the theory therefore predicted the snap-through process.

Further confirmation of the theory was obtained by undertaking tests in machines of different elasticities. A 200,000-lb. Riehlé screw-type testing machine proved to be sufficiently rigid to inhibit jump, but when an elastic dynamometer was introduced between the test column and the lower platen, there was a sudden drop in load at buckling, accompanied by an audible thud. The spring constant of the Riehlé machine was found to be about 10×10^5 lb. per inch without the dynamometer, and about $6{\cdot}7 \times 10^5$ with the dynamometer. Columns which had been tested in a Sonntag hydraulic machine having a spring constant of $1{\cdot}5 \times 10^5$ lb. per

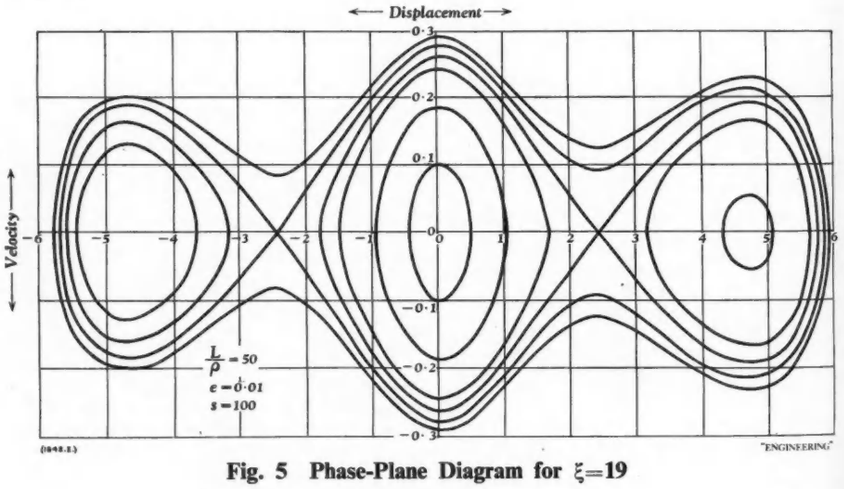


Fig. 5 Phase-Plane Diagram for ξ=19

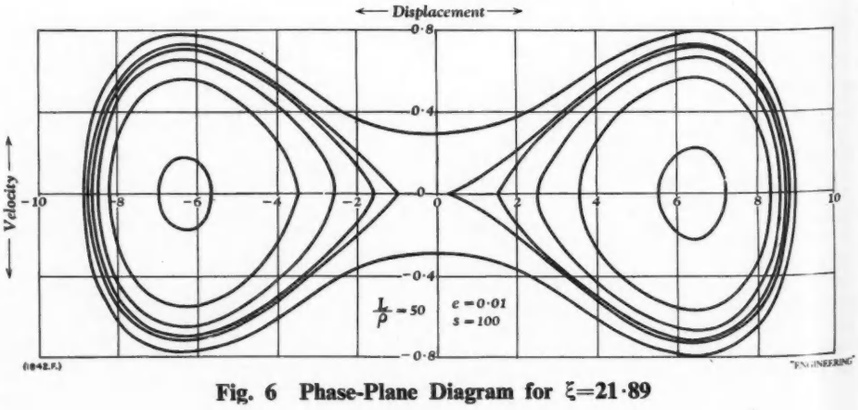


Fig. 6 Phase-Plane Diagram for ξ=21·89

* David Burgreen, "Free Vibrations of Pin-Ended Columns with Constant Distance between Pin Ends." *J. Appl. Mech.*, Vol. 18, No. 2, page 135 (June 1951).

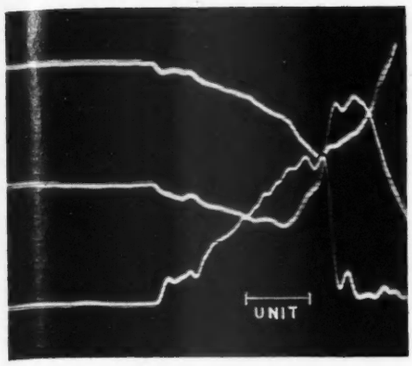


Fig. 7 Oscillogram of Rapid-Loading Test

The unit length shown corresponds approximately to 0·0025 *sec.,* 950 × 10^{-6} *strain, and* 558 *lb. load. The initial values of the strains are equal. They are projected apart for the sake of clarity.*

inch failed with a violent, and sometimes explosive, snap-through.

MACHINE FOR APPLYING RAPID LOADS

Turning to "rapid load application" which he distinguished from "impact-type loading," Professor Hoff outlined a method of theoretical solution and then described a machine which he had recently designed and constructed at Brooklyn for testing columns up to 13-in. long. "It is essentially a flywheel with an interchangeable cam which actuates a follower to depress rapidly the upper end of a column. The flywheel is brought up to full speed by a squirrel-cage induction motor rated at 2 h.p. at 1,680 r.p.m. The V-belt drive is arranged in such a manner that the maximum rotational speed of the flywheel is 2,000 r.p.m. The flywheel is mounted on a shaft of 3-in. diameter, which runs on ball bearings housed in heavy steel parts. A standard hydraulic automobile brake is provided to stop the flywheel. . . . When the flywheel is rotating at the desired speed, the operator throws a switch which actuates a trigger mechanism. The trigger brings the follower in position to engage the cam; a timing commutator is provided to ensure that this can happen only when sufficient time is available for the follower to become fully operative."

After explaining that this machine was still in the adjustment and calibration stage and that only a few preliminary tests had been made in it, Professor Hoff showed the oscillograph test record which is reproduced here as Fig. 7. The unit length shown corresponds approximately to 0·0025 sec., 950 × 10^{-6} strain, and 558 lb. load. The initial values of the strains are equal; they are projected apart for the sake of clarity.

The test specimen was an aluminium-alloy column having a solid rectangular cross-section of $\frac{1}{2}$ in. by $\frac{1}{4}$ in., and 11-in. long between knife edges. The slenderness ratio was 153; the initial eccentricity parameter, e, was 0·001, and the dynamic similarity number, Ω, was approximately 10.

The mean load was estimated by coupling strain gauges in series at the upper and lower ends of the column. The strains were measured on opposite sides of the middle of the column. Initially, all three quantities were zero, and they all made approximately linear deviations when the cam was engaged. "After about 0·0052 sec., one of the strains begins to increase more rapidly while the other indicates a strain reversal. At that moment the column starts to buckle; the maximum load is reached in about 0·0062 sec." The maximum load recorded in the test was about 1,350 lb., and, since the Euler load was 558 lb., the overload factor was about 2·4.

CREEP BUCKLING

From his work on creep buckling, which is still in progress at Brooklyn, Professor Hoff concluded that the critical time is comparatively little influenced by the initial crookedness of the column, so that uncontrollable inaccuracies of manufacture do not affect unduly the usefulness of the column. The critical time, however, is very sensitive to the magnitude of the applied compressive stress. Thus, if the load were decreased from 90 per cent. to 75 per cent. of the Euler load, the lifetime of the average column would be more than doubled. In consequence, the designer could greatly increase the safety of his structure by increasing only slightly the cross-sectional area of the column.

In conclusion, Professor Hoff discussed the terminology of failure in compression, referring particularly to inconsistencies in the use of the terms "buckling load," "critical load" and "collapse load." Thus, in his own words: "It may be said that the buckling load observed with a slender column when it is loaded slowly in the ordinary testing machine is, for all practical purposes, the critical load of the classical theory of stability. When the loading takes place very rapidly, this is obviously not true because the load reaches values far exceeding the critical load. A thin, rectangular, perfectly elastic plate supported along all four edges develops bulges so innocuously that the buckling load loses its physical significance; with such a plate the only load that counts is the collapse load, which is considerably higher than the critical load. Finally, the axially-compressed thin shell collapses at about one-third of the critical load. It is an oddity of accepted terminology that engineers are in the habit of considering as the critical load of the cylinder the experimentally observed buckling load, that is, the lowest load at which a sufficiently large disturbance is likely to provoke the snap-through process. In this case they are therefore perfectly willing to divorce the definition of buckling from the Eulerian theory of stability. At the same time they cling to the classical stability concept for the flat plate and refuse to accept the maximum load as the buckling load."

"This lack of consistency in terminology and accuracy in definition," Professor Hoff continued, "becomes even more apparent when the material is not perfectly elastic. This has been the cause of the controversy over the tangent modulus load as the correct stability limit." After discussing several proposed definitions he suggested that, in respect of one of these, "In a much less precise manner the engineer would express the same thought by saying that a system is unstable if the application to it of a very small force can produce a very large displacement. The emergence of such an entirely different criterion illustrates the point that there is nothing sacred about the classical definition of stability."

Professor Hoff's own view was that "It seems advisable to reserve the terms critical load and characteristic value of the load for the designation of theoretical loads at which the state of equilibrium is of a special character. Thus, the load at which the limit of stability is reached in accordance with the classical small-deflection theory, or even according to a large-deflection theory, is properly called a critical load. Common sense requires that the load at which a column or a thin-walled cylinder buckles suddenly in a loading process should be designated as the buckling load."

MEASURING FINE TEMPERATURE CHANGES

PROVISION OF A CONSTANT THERMAL DATUM FOR THERMOCOUPLES

By L. G. A. Sims, D.Sc., M.I.E.E.*

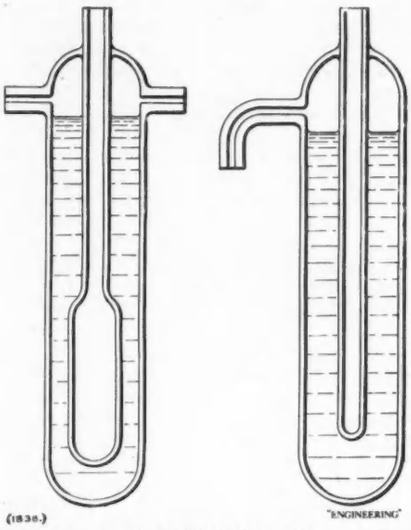
It is traditionally considered difficult to attain high accuracy in thermal measurements of the calorimeter type. For example, Sir Charles Darwin, F.R.S., writing quite recently in a memorandum to a Royal Society publication.† stated that "most calorimetric work has no very high accuracy." Again, to take an earlier example, namely that of the long history of the accurate determination of J, whole researches have had to be discarded because of uncertainty regarding their thermometry. Joule himself was disbelieved for many years upon similar grounds; but it is probable that some of the traditional sources of inaccuracy can now be removed.

It is well to consider anew the calibration of thermocouples and the provision of a very stable cold junction (or thermal datum) without which accuracy with the couple is impossible. For step-by-step calibration procedures, mercury-in-glass calorimeter thermometers to B.S.S.791 are now available, for 6 deg. C. temperature intervals (for example, 15 deg. to 21 deg., 18 deg. to 24 deg., and so on), over the range 9 deg. to 33 deg. C., graduated to 0·01 deg. C., and readable with a lens to a final count of 0·001 deg. C. The Beckmann adjustable mercury thermometer is also graduated in 0·01-deg. steps; but the Beckmann is essentially a difference thermometer and is rather difficult to adjust. Both these types of thermometer contain a considerable volume of mercury and have therefore a high heat capacity and are bulky. Nevertheless, they are entirely suited to accurate point-by-point thermocouple calibrations in, for instance, slowly cooling oil where their bulk and heat capacity are not disadvantageous.

Thermocouples are then often calibrated in terms of thermal e.m.f. and fractions of a degree Celsius against a Vernier-type direct-current potentiometer and a mercury-in-glass thermometer, preferably of the B.S.S. pattern mentioned above. A typical four-dial Vernier-type potentiometer has a lowest count of 0·1 microvolt, or about 0·0025 deg. C. temperature difference with a base-metal couple, but it is a high-resistance instrument and the galvanometer response may be poor at this low value of voltage unless an unusually sensitive galvanometer is employed. Furthermore, the Vernier potentiometer is really a meter-testing instrument with a full reading of 1·8 volts, intended for use generally about the 1-volt region and its circuit arrangements are not such as to exclude thermal e.m.f. due to friction

* University of Southampton.

† *The Unit of Heat*, issued by the Royal Society, October, 1950.



Two Forms of Triple-Point Water Cell – possibly the Ideal Cold-Junction Container for Thermocouples when a Constant-Temperature Datum of Great Accuracy and Stability over a Long Period is Required

heating at its own contacts, which might be important at very low microvolt readings.

The Diesselhorst potentiometer is really the correct instrument for use in calibrating thermocouples. It has a top reading of 100 millivolts and the same lowest count as the four-dial Vernier potentiometer, namely, 0·1 microvolt, but it has the advantage of a very low resistance internal circuit, is very free from parasitic thermal e.m.f.'s and is specially designed for use with thermocouples. With a sensitive galvanometer the lowest count of 0·1 microvolt can be further subdivided if desired by calibrating the galvanometer scale. If neither of these instruments is available the experimenter can, with some difficulty, devise other accurate means of calibrating thermocouples for small temperature changes, probably in the form of a sensitive reflecting galvanometer with its scale calibrated from a standard cell and standard megohm circuit.

The lowest count of a reflecting coil galvanometer of suitable resistance for working directly with a thermocouple in " static " calibrations will be of the order 10 mm. per microvolt at 2 metres, or of the order 0·0025 deg. C. per millimetre with a base-metal couple. With such a method amplification may be required. Where a steady or a slowly changing thermal e.m.f. is concerned, stable direct-current amplification is available, either by magnetic or by thermionic amplifiers. The lowest permissible input level is fixed by the noise level of the amplifier and this, in the case of a very sensitive amplifier, is of the order 0·25 microvolt, or about 0·006 deg. C. with a base-metal couple ; but if a chopper amplifier is introduced, it is claimed that 0·01 microvolt can be handled, or 0·00025 deg. C.

For fine temperature-change readings at high accuracy, the cold junction or temperature-datum element should be closely at the same temperature as the hot junction to eliminate temperature gradients in the connecting wires, the metal of which may be sufficiently non-homogeneous to set up thermal e.m.f. changes of the same order as that being measured. For the same reason, the wires should preferably be screened from air currents and otherwise kept at a constant temperature. With these precautions, however, base-metal couples are probably capable of reproducing absolute temperatures reliably to 0·01 deg. C., or temperature differences reliably to 0·0001 deg. C., depending upon how great is the gradient between hot and cold junctions. This assumes a perfectly constant cold junction.

COLD JUNCTION OR THERMAL DATUM

In thermocouple measurements, it is usual to employ melting ice in a vacuum flask as a cold junction and this technique is capable of great temperature constancy but it should be applied with due regard to the fact that the ice point absolute temperature may vary if precautions are not taken ; also the use of the ice point as a datum means, in general, a considerable temperature gradient along the couple wires. Further, the ice point changes by 0·001 deg. C. per 10 mm. change in barometric height and by about 0·002 deg. C. as between saturated and air-free ice. The ice point also changes by about 0·001 deg. C. per 6 in. of immersion in melting ice due to change of hydrostatic pressure.

The most satisfactory cold junction for short periods of time, and particularly when two or more cold junctions are involved, is probably the high-conductivity high thermal inertia unit in the form of stirred oil in a vacuum vessel, or better in the form of a copper or other metal mass monitored by a 0·01 deg. C. mercury-in-glass thermometer (sensitive in the final count to 0·001 deg. C., as mentioned above) observed preferably through a vertically-travelling microscope. The oil or the metal block should be in the vicinity of the test object for five or six hours, preferably overnight, so as to attain the same temperature as the test object. They can then be vacuum enclosed to assist in maintaining that temperature during the test. For example, a copper-block cold junction has been used in the highest grade metrology of engineering gauges. With this apparatus measurements of 0·000,001 in. in 1 ft. are achieved, or 0·002 deg. C. Without knowledge of this, for some time past we have been devising and constructing a similar though more massive copper unit.

A possible thermal datum of much interest is the triple-point water cell, for which a long-period absolute temperature value of better than 0·01 deg. C. $\pm$ 0·0001 deg. C. is claimed by the National Physical Laboratory and also by the National Bureau of Standards.* Moser, at the Berlin Physical Laboratory, found the triple-point water cell to be constant to 0·000,05 deg. C.

These cells, which are robust, are of glass about 30 cm. long and 4 to 7 cm. in diameter, with a re-entrant glass tube well to take a mercury-in-glass thermometer, but which could also take one or more cold junctions. The general arrangement of two forms of the triple-point cell is shown in the accompanying sketch. The cells contain no air but only pure water, ice and water vapour, and because the equilibrium vapour pressure is only $4\frac{1}{2}$ mm. Hg, the temperature is that of melting ice under about 1 atmosphere less pressure than the usual ice pot. This accounts for about + 0·0075 deg. C. difference from 0 deg. C., the total difference being 0·01 deg. C. (the remaining 0·0025 deg. is said to be due to air in the ice of the ice-point vessel).

The cell is itself immersed in an ice-point cabinet and it is difficult to imagine a better form of cold-junction container than such a cell where only extreme constancy of temperature is concerned. For measurements in the region of the ambient laboratory temperature, however, there would still be the great difficulty of some 20 deg. C. temperature gradient along the couple wires, together with an unwanted standing thermal e.m.f. of about 800 microvolts.

Present investigations with which the author is concerned conveniently employ thermocouples, and since the properties under investigation vary appreciably with temperature, it is desirable to measure them using small temperature differences and it is preferred to aim first at the smallest feasible values. It is felt that study of the matter upon the above lines leads to the conclusion that accuracy might be achieved on 0·01 deg. C. measurements to approximately 1 per cent., but this demands a thermal datum constant for several minutes to approximately 0·0001 deg. C., and represents about the limit of performance of a base-metal couple or a cold junction. On the other hand, it may be fairly stated that this degree of sensitivity, contributes to high accuracy in calorimetry.

* *See* " The International Temperature Scale of 1948," D.S.I.R. publication. Additional references to the subject of this article are: " Discussion upon Temperature Measurement," Institution of Electrical Engineers (1950). " Some Experiments with Pure-Metal Resistance Standards," and " Productivity of the Ice Point," both by J. L. Thomas, *Bureau of Standards Journal of Research*, vol. 12 (1934).

SINTERING OF IRON ORE

Immediately after the Autumn General Meeting of the Iron and Steel Institute, which took place in London on November 24 and 25, a Symposium on Sinter was held on the afternoon of November 25 and during the whole of November 26. The President of the Institute, Mr. James Mitchell, C.B.E., occupied the chair. At the first session five papers were discussed jointly after presentation by their authors. They were " Sintering as a Physical Process," by Dr. H. B. Wendeborn; " The Mechanism of Reduction of Iron Oxides," by Mr. J. O. Edström; " The Softening of Iron Ores at High Temperatures," by Mr. A. Grieve; " The Chemical Constitution of Sinters," by Dr. R. Wild; and " Radiographic Studies of the Process of Sintering of Iron Ores," by Mr. E. Cohen.

ABSTRACTS OF PAPERS

In the first paper on " Sintering as a Physical Process," the author, Dr. H. B. Wendeborn, of Frankfort-on-the-Main, Germany, stated that, in the course of sintering, the ores were successively exposed to different temperatures, so that a sintering charge was divided into a number of parallel zones, called " differential layers," each of which had a different temperature. The travelling speeds of these temperature zones within the charge were a function of the fuel content and grain size, the reaction work to be performed, the gas resistance of the ore at the different temperatures, and the speed of the air flow through the charge. The temperatures created during sintering were an integral function of the heating sequence in the charge strata, during which the addition of the heat of combustion in the upper strata to that in the lower strata caused a typical heat accumulation. The function of the air current was therefore mainly that of a heat-conveying medium; part only of the air current effected, in addition, an intensified combustion of the preheated fuel. Measuring and plotting, against time, the instantaneous values of the waste-gas temperature (and especially the temperature at a point within the charge) offered a convenient way of observing the behaviour of the ores, as well as the efficacy of the measures taken, and was also useful for checking the thermal intensity of the process.

The second paper, entitled " The Mechanism

of Reduction of Iron Oxides," was by Mr. J. O. Edström, of Stockholm. He stated that he had studied the reduction of pure, natural hematite and magnetite crystals by hydrogen and carbon monoxide, mainly with the aid of the microscope. The low strength of pure hematite ores and of well-oxidised, burnt, rich-ore pellets during reduction with carbon monoxide was due to the formation of pores, accompanied by a considerable expansion and a disintegration of the structure. The minimum reaction velocity above 600 deg. C., when Fe_2O_3 and Fe_3O_4 were reduced by hydrogen, was associated with the appearance of dense continuous layers of wüstite—an iron-oxygen constituent unstable below 570 deg. C., when it decomposed eutectoidally into α-Fe and Fe_3O_4.

The third paper, " Softening of Iron Ores at High Temperatures, was by Mr. A. Grieve, of the B.I.S.R.A. blast-furnace research laboratory, Imperial College, London. The author stated that an apparatus had been constructed to study the softening behaviour of iron ore at temperatures up to 1,480 deg. C. This had enabled the softening behaviour of any ore or agglomorate to be determined under different conditions of reduction and loading. The softening temperature and range had been related to the amount and composition of the gangue and to the ferrous oxide content. The combined presence of silica and ferrous oxide led to fayalite formation and rapid softening. The degree of reduction beyond the magnetite stage (11·1 per cent.) had a major influence on the softening rate, with a pronounced maximum between 20 per cent. and 30 per cent. reduction. For a given percentage reduction, the softening rate was greatest for a homogeneously-reduced ore. The effect of load in the range studied (6·1 lb. to 10·6 lb. per square inch) was slight. The possible harmful effects of softening would be minimised under the following conditions of working: (*a*) Indirect reduction of the ore in the stack beyond the critical reduction of 20 to 30 per cent. (*b*) The use of a mixed burden so that softening occupied a greater temperature range. (*c*) The operation of the furnace up the walls rather than up the centre, so as to avoid scaffold and arch formation in the stack.

The fourth paper dealt with " The Chemical Constitution of Sinters " and was by Dr. R. Wild, who stated that the chemical constitution of a number of commercial sinters and of sinters produced in the B.I.S.R.A. experimental sinter box, from both lean and rich ores, had been found by X-ray powder diffraction photography. The strength of the sinters from lean ores decreased with increasing ferric oxide content and increased with increasing ferrous silicate content. The reducibility of these sinters decreased as their strength increased. It was very small when an appreciable quantity of silicate was present. Reasonable strength was not attained with sinters made from home ores unless some silicate were present, which suggested that the silicate played an important part in the bonding. With sinters made from rich ores the strength was independent of the ferric oxide content and a sinter of reasonable strength could be obtained without the presence of any detectable amount of silicate. The presence of appreciable silicate in the sinter, however, did give added strength. Nevertheless, the greatest reducibility was found where the ferric oxide content was greatest.

" Radiographic Studies of the Process of Sintering Iron Ores " was the title of the fifth paper ; it was by Mr. E. Cohen and was submitted by the B.I.S.R.A. Sintering Sub-Committee. The author stated that he had used micro-radiographs to study sinters and that four tentative conclusions could be drawn from his work. The first was that the presence of lime in sinter mixtures which contained no free silica would prevent the formation of fayalite and other iron silicates. Secondly, if the sinter mixture contained free silica, an addition of lime would prevent the formation of fayalite, but a mixed calcium-iron silicate was formed. Thirdly, the presence of lime usually resulted in the temporary or permanent formation of monocalcium ferrite in the sinter. The formation of this mineral and the suppression of iron silicates appeared to be closely connected. Fourthly, the addition of lime to " difficult " sinter mixtures was more beneficial than further additions of fuel, because lime speeded up the process, whereas more fuel merely raised the peak temperature reached by the sinter. The fuel content should always be kept to the minimum that would produce sufficient bonding slag.

DISCUSSION

Mr. R. F. Jennings, who opened the discussion, said that the value of returned fines as a means of diluting the chemistry of sintering when strong endothermic reactions were a part of the process was a most interesting point. It added yet another argument in favour of using a high proportion of the returned fines with British home ores. The marked effect of lime addition to a siliceous ore in reducing the sintering time still seemed difficult to understand. Dr. Wendeborn's argument that this was due to improved gas permeability in the sintering zone seemed to be insufficient to account for the very great improvement obtained by a 5 per cent. lime addition. Surely the lime allowed the flame front to advance more quickly by activating the ignition process in some way.

Present sintering practice in this country had not generally reached the limiting gas speeds suggested by Dr. Wendeborn and suctions rarely reached the 1,000 mm. of water gauge which he considered the economic limit. If the permeability formula developed by Voice and his colleagues were used to predict the relation between suction and output, it would be seen that there was fairly close agreement between such calculated values and the output curves shown by Dr. Wendeborn.

Mr. E. W. Voice said that Mr. Cohen's results on the use of lime additions were very interesting because other work had shown that the additions of lime to certain ores had resulted in much quicker sintering. His observation that a mono-calcium-iron silicate was formed rather than fayalite was of importance in connection with reducibility considerations. It was well known that hematite was more readily reducible than magnetite. Some operators in this country had found little disadvantage from less reducible sinter—was this because any advantage from reducibility was offset by the disadvantage of reduced strength in the lower stack or bosh ? It might well be that this happened with the high furnaces in use in this country. Mr. Grieve had concluded that the harmful effects of softening might well be reduced by working the furnace up the walls rather than up the centre. To throw further light on so many points which had been raised, it was desirable to obtain much more information from actual furnaces concerning their modes of operation. Some work he had done some years before had convinced him that one furnace working on Northamptonshire ore did, in fact, operate up the centre for the first week or two after blowing in, but thereafter it changed and continued to operate up the walls for the remainder of the campaign.

Mr. Sven Fornander stated that, in Sweden, importance was attached to the results obtained by Mr. Edström. He had shown that, in the reduction of hematite, a porous FeO phase was obtained and that, in the reduction of magnetite, a dense FeO phase was formed. He had also shown that the rate of reduction was highly dependent on the porosity of the FeO phase, the reduction rate being much higher the greater the porosity of the FeO phase. It was an old experience in Sweden that if it were desired to operate a blast furnace on a low coke rate the burden should consist of 100 per cent. sinter and, perhaps still more important, a sinter having a high degree of oxidation, namely, having a high content of Fe_2O_3. Later in this Symposium Mr. C. Danielsson would tell the meeting that he was operating his furnaces with coke rates of the order of 1,200 to 1,300 lb. per net ton.

Miss E. M. McBriar said that, at the Research and Development Department of the United Steel Companies, ironstone sinters produced from mixtures of Frodingham and Northamptonshire ores had been studied. These had been made on the Dwight-Lloyd strand at the Appleby-Frodingham works, and on a miniature sinter plant at the Swinden Laboratories. These ores were low-grade and contained a considerable amount of alumina. The non-ferrous constituents combined to produce a silicate bond in the sinter which had a composition similar to that of the slag of the blast furnace. An average analysis of the silicate in their practice, considering only the four main components, recalculated to 100 per cent. was: 40 per cent. CaO, 36 per cent. SiO_2, 4 per cent. MgO and 20 per cent. Al_2O_3.

Mr. J. Astier referred briefly to two points. First, with regard to the softening of iron in sintering, some tests had been made in France on the softening of sinters made from Minette ore; and he stated that it had been found that, generally speaking, there was a beginning of softening for every type of sinter between 900 deg. C. and 1,000 deg. C. Secondly, with regard to the relationship between the degree of oxidation of the sinter and the properties of the sinter, especially in the blast furnace, it had always been found with Minette ore that there was a direct linear relationship between the porosity of the sinter and the degree of oxidation.

Dr. B. G. Baldwin said that anyone who was familiar with the reduction of iron-bearing materials would know of the vast amount of work which had been published. The majority of this work had been carried out on the reduction of iron ores, of varying purity, and it was important to carry out experiments on pure materials if the purpose of the investigation were to study the mechanism of the reduction of iron oxides, and this Mr. Edström had done by using single crystals of magnetite and hematite. In his (Dr. Baldwin's) opinion, it was not correct, when comparing the reduction of a hematite and a magnetite, to express both results on the same graph of percentage reduction against time, since, compared with the hematite, the magnetite was already 11 per cent. reduced. He also thought that a somewhat clearer picture of the way in which the reduction proceeded was given if the results were expressed in the form of a graph of the rate of removal of oxygen per minute, against total oxygen removed, for a standard weight of material. The strength of pellets containing 0·5 per cent. of lime had been found to be greater than that of those without lime, and the possibility that the increase in strength was due to the presence of calcium ferrite was made.

Mr. A. Grieve said that in Dr. Wild's paper the presence of quite large amounts of calcium ferrous silicate (iron monticellite) was reported in certain home-ore sinters. Experiments on the rate of reduction of this and related compounds had been made at the Imperial College. When mixtures of equal amounts of lime and fayalite were rapidly heated with carbon to tem-

peratures above about 1,175 deg. C., there was an initially-high reduction speed, after which the rate fell off to a very low value even above 1,300 deg. C. Under these conditions the lime displaced half the ferrous oxide in the fayalite at the expense of fixing the remainder as iron monticellite, which was much less reducible than fayalite itself. Similar results were obtained using mixtures of lime, ferrous oxide and silica in place of lime and fayalite.

Dr. H. B. Wendeborn replied briefly to some of the points raised on his paper. Mr. J. O. Edström, who also replied, said that he had been asked whether he had seen any cubic or other intermediate structure when oxidising magnetite to hematite. He had only oxidised it at high temperatures, about 1,100 deg. C., but he had seen in other papers on this subject that cubic hematite did not form above 500 deg. C.

Mr. A. Grieve, in his reply, agreed with Mr. Voice that more knowledge was needed before it was possible to be dogmatic concerning the effects of the softening of ores in furnace operation, and this knowledge could certainly only be obtained by much extended furnace exploration techniques. With regard to the absence of softening problems with high sinter burdens, this was probably due to its very sharp and very low melting range. With regard to the softening of Minette ore, he found it difficult to see how true softening could occur at temperatures as low as 900 deg. C.—at least, supposing that softening entailed the formation of an incipient molten phase. At these low temperatures, with the leaner home ores considerable shrinkage might occur, but this was always followed by a levelling out before true softening began. In his reply, Dr. R. Wild said that one point with which he might perhaps deal in a little more detail was the question of iron monticellite found in considerable quantity in the sinters made from Northamptonshire ore. A considerable amount of work had been done on the calcium ferro-silicates and calcium silicates in the laboratories at South Kensinton since the publication of his paper, and it had been found that iron monticellite was probably a compound under the prevailing conditions of temperature.

Mr. E. Cohen, in the course of his reply, said that the alumina which occurred abundantly in some of the home-ore sinters was an important constituent and formed various crystalline phases, but it seemed that alumina was a very passive partner in the sintering process and there was no evidence that alumina had a distinct influence on the process of sintering. If it went into the melt and that melt reached equilibrium, then appropriate constituents would form, but the presence or absence of a certain percentage of alumina did not seem to have any great effect on the process of sintering as such. The effect of lime in sintering was not quite clear. It might be that, provided no free silica were present in the sinter, lime produced a solid and stable phase during the heating up of the sinter mixture at a temperature when that mixture would otherwise be fluid and dense—i.e., above 1,100 deg. C. and below 1,210 deg. C. In this stable phase the monocalcium-ferrite was quite stable, and the increased permeability of the sinter bed might be partly due to the presence of this solid phase in the place of the liquid slag which would prevent the passage of gases. On the other hand, in instances in which free silica was present in the sinter mixture, this effect of lime had not been shown, and the presence of monocalcium-ferrite had not been found. It did seem that the free silica prevented the formation of monocalcium ferrite during the heating up of the sinter.

To be continued

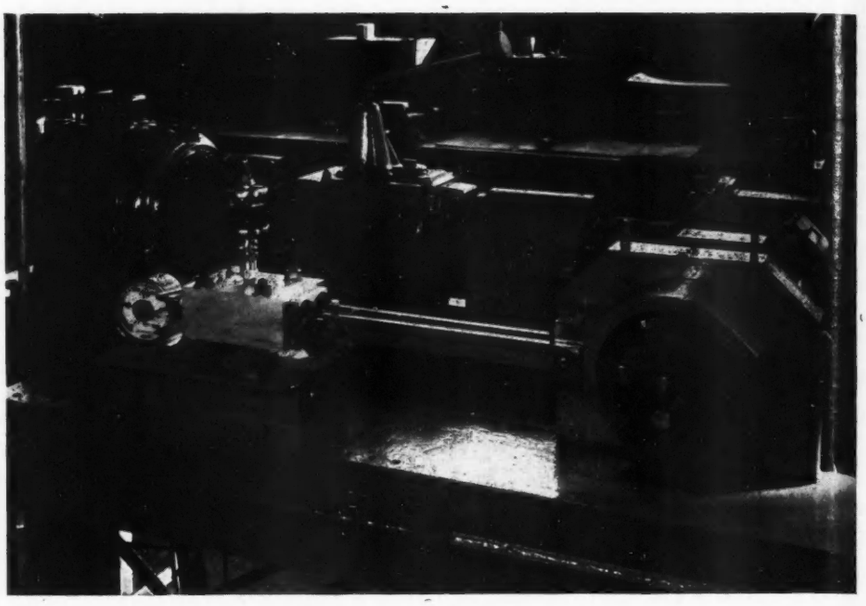


Fig. 1 Machine for Reciprocating Tests on Sealing Materials, etc. Used for Endurance Tests of a Million or More Cycles.

TEST AND RESEARCH RIGS

APPLICATIONS TO AIRCRAFT EQUIPMENT

APART from a description of a method of hard anodising light alloys (to produce a good wearing surface suitable for journals), this article deals with a number of test and research rigs which are used by Dowty Equipment, Limited, Cheltenham. Investigations are carried out on fluids, synthetic rubbers, and metals, as well as on components such as pumps, jacks, valves, hydraulic pit props, aircraft undercarriages, and aircraft hydraulic systems. The rapid developments in undercarriage design which have taken place since the war, combined with the effects of the widening temperature range which high-speed aircraft have to withstand, have led the firm to employ the rigs described here. The tests cover static and dynamic strength, wearing qualities, correct functioning and endurance, and causes of service failures.

STATIC STRENGTH TESTING

For checking the static strength of test-pieces, castings, forgings and complete assemblies, there are four hydraulic structural test machines : a 30-ton Avery universal machine for test bars and small components ; a second 30-ton adjustable machine for larger components, extending up to the ceiling of the test house and controlled from the same control cabinet as the universal machine; and 20-ton and 100-ton compressive frames both of which have been constructed by the Dowty company to suit their own testing requirements.

Hydraulic pit props, as well as undercarriage components, are tested in the 100-ton test frame, which is designed to take components of large dimensions. The applied load is determined either by measuring the hydraulic pressure on the ram, or by an extensometer which measures the extension of the vertical tie-bar of the frame under the load transmitted by the top cross-member. A conventional Martens mirror extensometer is used for this purpose. A strain-gauge terminal box, with provision for plugging in up to 50 resistance-wire strain-gauge leads is mounted on the frame and is wired permanently to the strain-gauge control room, which houses the bridge circuits, selection switch and galvanometer indicator.

In addition to tests on synthetic-rubber seals and their behaviour in the presence of hydraulic fluids and lubricants, routine determinations of the properties of the various oils and fluids and metallurgical examinations on failed parts are carried out in the laboratory, which also controls the composition of the plating and heat-treatment baths used in the factory. One of the most useful pieces of apparatus in the laboratory is a Watson projection microscope with a camera attachment. Among its more unusual applications is the routine testing of brass-plated gudgeon pins employed in Meteor undercarriages, to check the adhesion, porosity and thickness of the plating.

HARD ANODISING OF LIGHT ALLOYS

In the laboratory, work on new chemical processes for the company's products is also carried out. During the last few years the department have successfully developed a hard anodising process for light alloys, and in addition to a pilot plant in the test house, a small production plant has now been installed in another

works. Although the hard anodising process does not produce such a good sealing surface as chromium plating, and will not withstand point loading, it can be polished to give an excellent journal surface with hard-wearing and anti-corrosive qualities, and is used, for example, on the company's Hydel valve faces and also in the sliding tube of the Avro Vulcan shock-absorber leg. The hard-anodising process produces a film thickness up to 0·004 in. (in comparison with about 0·0002 in. by normal anodic treatment) of which about 0·0022 in. extends into the pores of the metal, and about 0·0018 in. is built up above the metal surfaces. This build-up can be usefully applied in salvaging operations on worn or badly fitting parts.

The hard-anodising process consists, briefly, in an anodic treatment in a sulphuric-acid bath at a temperature between 0 and 2 deg. C., at a constant current of 2·5 amperes per square decimetre for 1 to 1½ hours. As the anodic film builds up, the electrical resistance increases, and therefore the voltage has to be progressively raised from about 20 volts initially up to 60-80 volts, depending on the desired thickness. When the latter has been attained, the surface of the porous anodic film is sealed by soaking for 5 to 10 minutes in nearly-boiling water or in hot wax. The sealed coating forms quite an effective electrical insulation.

EXTREME-TEMPERATURE TESTS

One section of the test house is devoted to testing components of hydraulic systems, and to establishing satisfactory lives for the synthetic-rubber seals and glands employed in them. In the case of aircraft hydraulic systems, these seals have to withstand temperatures which may range between −50 deg. to +80 deg. C., and in the near future with supersonic aircraft this range is likely to be extended up to + 150 deg. C. For testing fluids, seals and small components at high temperatures, an oven provides for temperatures up to 300 deg. C. The test house is also equipped with a refrigerator which enables functioning tests to be carried out at temperatures down to −54 deg. C., employing Freon 12 as the refrigerant. It is possible to lower the temperature of the cold chamber still further down to −60 deg. C., by inserting trays of solid carbon dioxide. There is provision for mounting a hydraulic pump and reservoir within the cold chamber, the drive being through a layshaft passing through a sleeve in the refrigerator wall. This avoids introducing hydraulic fluid at ambient temperature into the cold chamber, and also serves for testing the operation of the pump itself at low temperature.

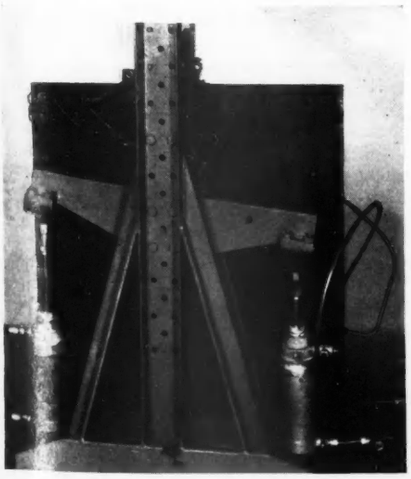


Fig. 2 "See-Saw" Rig for Endurance Tests on Hydraulic Jacks. Fluid is pumped into one while Fluid from the other, which acts as a Loading Medium, passes out through an Adjustable Relief Valve.

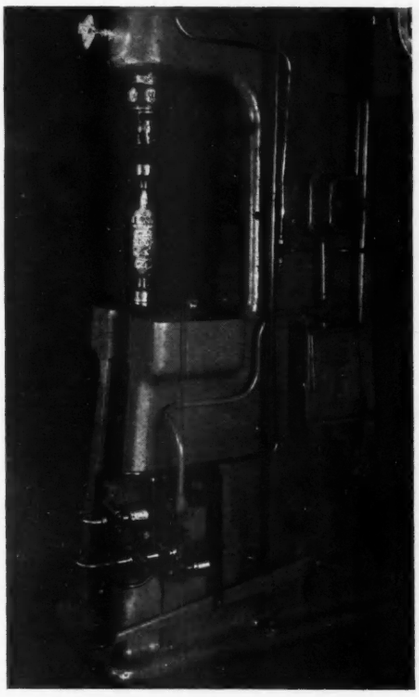


Fig. 3 12-Ton Hydraulic Press fitted with Reversing Mechanism for Testing Shock Absorbers. The Test Cycle is Repeated Automatically.

"SEE-SAW" RIG FOR HYDRAULIC JACKS

Special rigs are provided for life-testing pumps, jacks and complete shock-absorber legs. There are two hydraulic pump test-beds, one of which provides a variable-speed drive from 350 r.p.m. to 4,000 r.p.m., the other, driven by a reversible motor with a four-speed gearbox, at speeds ranging from 775 r.p.m. to 2,940 r.p.m. The "see-saw" rig illustrated in Fig. 2 is used for endurance tests on hydraulic jacks ; one jack is actuated by a Dowty "Live-Line" pump, and the other jack forms a hydraulic loading medium, discharging through a relief valve which can be adjusted to give any desired line pressure up to 4,000 lb. per square inch. At the end of the stroke, a micro-switch operates a reversing valve in the actuating circuit and reverses the flow direction to the driving gear. On its return stroke, oil is drawn into the driven jack through non-return valves. This rig can be accommodated in the refrigerator for low-temperature investigations. In an older jack-testing rig, driving and driven jacks are horizontally opposed, and the reversing valve is mechanically actuated.

RECIPROCATING TESTS

In the early development of new components and sealing materials, it is often necessary to prove them in long-term endurance tests extending over a million or more operating cycles. To facilitate such tests, an accelerated "push-pull" machine illustrated in Fig. 1 has been constructed, enabling 100, 250 or 300 cycles per minute to be performed. The reciprocating head is actuated by a variable eccentric with a stroke range from 0·1 in. to 2·5 in., driven by an electric motor through a reduction gear and a three-speed automobile gearbox, the component under test being hydraulically loaded under a pressure of 4,000 lb. per square inch. All the life-testing rigs are equipped with counters automatically recording the number of cycles performed.

HYDRAULIC PRESS WITH REVERSING MECHANISM

Much of the early work done on the liquid-spring shock absorber, a description of which was given on page 289 of our 164th volume (1947), was carried out on two hydraulic presses, of 12 tons and 100 tons capacity, respectively, with automatic cycling equipment. Complete liquid-spring shock-absorber units are tested on these machines to determine the wearing qualities of the piston rods and the life of the cylinders and glands.

The 12-ton press, of the Drummond Electraulic type, is illustrated in Fig. 3. The automatic reversing mechanism, which can be seen at the base of the press, was designed and fitted by Dowty Equipment, Limited, and consists of a mechanical tripping device operated by a spring-loaded plunger when the ram pressure reaches a preselected value. The pressure at which the changeover valve is actuated can be adjusted by varying the spring load ; the ram stroke varies accordingly to a maximum of about 12 in. The reversing mechanism incorporates an overload device which cuts off the electric power driving the hydraulic pump. In the 100-ton Daniel press, the reversal of the ram is controlled electrically by an adjustable pressure switch.

Other equipment in the hydraulic section of the test-house includes a rig constructed originally for the functional testing of air compressors, but now used mainly for testing air valves and small pneumatic components. It is equipped with pressure gauges, a Rotameter flow meter and a 12-point Nottingham temperature recorder. For measuring very small air flow rates, down to 0·01 cub. ft. per minute, equipment similar in principle to a gas-holder is used. A counter-balanced cylinder floating in a cylindrical container is displaced by the incoming gas, the

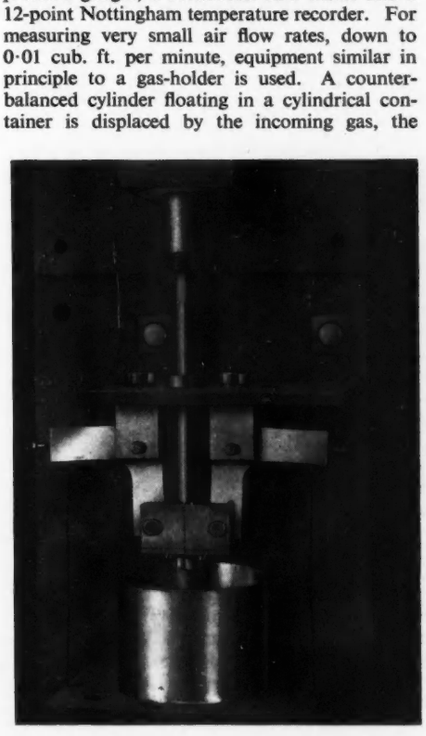


Fig. 4 Machine for Assessing Frictional Behaviour of Two Materials which are in Rubbing Contact and Immersed in a Fluid. The Vertical Bar is made of one Material. Two V-Blocks with Inserts of the other Material are Pressed against it by Weighted Bell-Cranks. The Assembly is Immersed in the chosen Fluid.

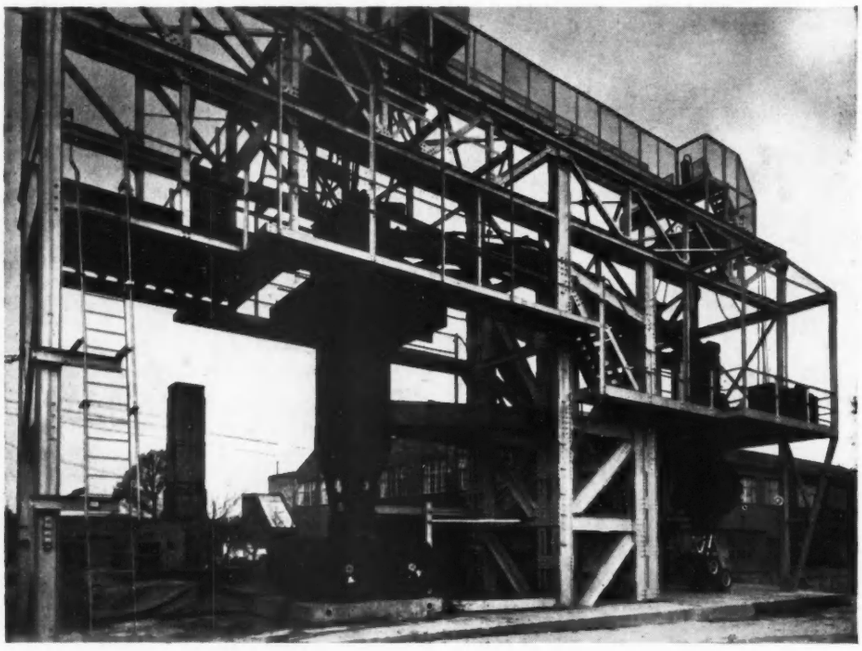


Fig. 5 Double Rig for Drop Tests of Aircraft Undercarriages

amount of its displacement being indicated by a geared pointer on a dial gauge, and the pointer movement being timed by stop watch.

MEASURING DIFFERENTIAL PRESSURES

For calibrating the resistance of pipe-lines, a differential pressure gauge is employed consisting of a double-ended piston which moves in response to the pressure drop in the length of pipe-line under test. The out-of-balance force on the piston is balanced by a steelyard, enabling differential pressures from 1 lb. to 300 lb. per square inch to be measured under an overall pressure of 2,500 lb. per square inch. Provision is made for recording the differential pressure, the overall pressure and the temperatures at the inlet and outlet to the test length of pipe. The rate of flow can be determined from the amount of oil delivered over a preselected time interval. The rig is supplied by a controlled-delivery Live-Line pump delivering up to 8 gallons per minute. To avoid the use of T-pieces for tapping the pressure from the test length to the gauge, which would introduce turbulence and result in a false indication, at the start and finish to the test length the piping is drilled with four small holes which are surrounded by a muff from which a branch pipe leads to each side of the piston, thereby transmitting the true static inlet and outlet pressures.

FRICTIONAL BEHAVIOUR OF TWO MATERIALS IMMERSED IN A FLUID

A recent addition to the hydraulic test equipment is the small friction-test machine illustrated in Fig. 4, which has proved to be valuable in the early stages of development work in assessing the frictional behaviour of various combinations of material in various hydraulic fluids or fuels, and the effects of surface treatment and finish. A cylindrical bar specimen of one of the metals, arranged vertically, is driven at the appropriate rubbing speed by a variable-speed electric motor. Friction is applied by two stationary V-blocks in which are pressed inserts of the other metal to be tested, forming rubbing faces. The V-blocks, which are pivoted on bell cranks, are almost in line contact with the cylindrical specimen; the actual width of contact is about 0·01 in. The whole V-block and bar assembly is immersed in the test fluid. To provide the correct bearing pressure, the V-blocks are loaded by weights suspended on the bell cranks.

Another small rig is used for checking that switches and similar components maintain correct contact under vibration. The switches, which are wired to indicator circuits, are mounted in a rectangular plate of light alloy which is suspended at each corner by springs. At its centre, the plate supports an out-of-balance mass which is rotated by a variable-speed electric motor at speeds up to 9,000 r.p.m.

Large hydraulic test rigs are available outside the test-house for carrying out functioning and endurance tests on a complete aircraft hydraulic system, e.g., the undercarriage and its doors, the flaps and bomb-door circuits, etc., together with the pumps and accumulator, and ensuring that the various operations are carried out in their correct sequences and that no undesired interconnections occur between individual circuits. In some cases, strain-gauge recordings are taken during the functioning tests. The pipe runs, so far as possible, are identical with those in the actual aircraft, and the external loads on the actuating jacks are simulated by springs or dead weights. In the case of the Avro Vulcan system which has recently been under test, the electrical load from the hydraulic services was considerable, and it was necessary to instal a local transformer station to provide power.

TESTS OF UNDERCARRIAGES

In order to ensure that the undercarriage provides the necessary energy absorption without exceeding the permissible ground reaction under the most severe combination of vertical, drag and side loads, " drop " tests of complete undercarriage units are carried out, during which measurements are taken of the total movement of the unit, the deflection of the shock absorber, the tyre deflection and the acceleration. The test department is equipped with four undercarriage drop-test rigs. The outdoor double rig illustrated in Fig. 5 is probably the largest test frame of its type that has yet been constructed. In the centre can be seen the frame installed after the second World War for carrying out drop tests on the undercarriage of the 130-ton Bristol Brabazon air-liner. In 1950 this equipment was extended to include the frame shown at the right, for testing landing gear of aircraft with all-up weights ranging from 80,000 lb. to 160,000 lb. The Comet and Vulcan undercarriages have been proved on this rig.

The Brabazon test rig is of the swinging-frame type in which the undercarriage attachment brackets are secured to a moving vertical frame which is carried by two swinging parallel longitudinal arms, of triangular planform. The lower and upper arms are pivoted at their rear ends on 8-in. and 6-in. diameter pins which fit in phosphor-bronze bushes in a massive vertical fixed frame which takes the whole of the vertical reaction, amounting in the case of the Brabazon to a maximum of 100 tons. The rear frame is carried on a steel grillage, the main members of which are 15-in. by 6-in. rolled-steel joists 17 ft. long secured by 1-in. foundation bolts 3 ft. 6 in. long to a 1-in. plate embedded in a concrete foundation block 6 ft. deep. Spanning the moving parts of the frame are two Warren girders, supported on the rear frame and a lighter forward frame which is anchored by foundation bolts 2 ft. 9 in. long in mass concrete 5 ft. deep, extending over an area 14 ft. by 4 ft. The Warren girders carry cross-beams on which is mounted the hydraulic lifting gear for the moving frame.

The moving frame, which is 5 ft. wide, is provided with a platform to which can be added cast-iron masses, giving a range of falling weights from 20 to 40 tons. The rig is provided with access and loading galleries to enable these adjustments to be carried out. A reinforced concrete platform 4 ft. 6 in. thick, 15 ft. long and 12 ft. wide, receives the undercarriage during the drop. It is surrounded by an anti-vibration fibre expansion joint. At the top end, the moving frame is attached by a hydraulically-operated quick-release gear to the ram of a hydraulic cylinder which raises the moving frame in readiness for a drop test. The hydraulic cylinder is approximately 8 in. in diameter, and is operated at 3,000 lb. per square inch by a Dowty pump driven by a 7½-h.p. motor. The cylinder is fitted with a hydraulic lock which enables the moving frame to be held while adjustments are made to the gear under test; the lock is released by a hydraulic hand-pump. The quick-release gear for the swinging frame consists of a hook, mounted on high-tensile steel rollers, and held by a toggle which is operated by a hydraulic jack supplied by a hand-pump. Before the hook can be disengaged, a mechanical safety latch must be released, thus ensuring that the men on the hydraulic controls cannot operate the quick release inadvertently while others are still in the way of the swinging frame.

The 80,000-lb./160,000-lb. rig employs an identical hydraulic cylinder and ram for lifting the moving frame, actuated by a hydraulic pump. The rear frame of the smaller rig was attached to that of the Brabazon frame above ground level, thus avoiding interference with the existing grillage, and the Warren girders were extended rearwards to accommodate the hydraulic jack. Both frames can be in use together, provided that the drops are not made simultaneously. Overhead gantry beams, provided with travelling hoists, span the length of the double rig. To relieve the load on the jacks and release mechanisms, steel wire slings suspended from the jack-supporting cross-beams hold the moving frames in the raised position for long periods.

To provide drag-load and side-load effects,

in the case of single-wheel undercarriage units, concrete wedges with the top surface at a suitable angle are located below the moving frame. With multiple-wheel bogie under carriages simple wedges cannot be used; for reproducing side loads, a sliding wedge platform is used. A pair of upper moving wedges, carrying a horizontal table on which the " landing " is made, slides on rollers on lower wedges mounted on a fixed table, the sliding and fixed wedges being linked together by springs. Drag loads are simulated by spinning up the wheels of the undercarriage backwards, to a peripheral speed of about 140 m.p.h., using an aluminium-alloy pulley inserted between the bogie wheel and driven by a 25-h.p. slip-ring motor at 2,940 r.p.m. The motor and pulley are mounted on a Lansing-Bagnall fork-lift truck so that they can be easily raised to any required height to spin up the wheels before the undercarriage is dropped. The wheels are overspeeded, the motors are withdrawn, the speed is checked by stroboscope, and at the desired speed the quick-release mechanism is actuated.

Two smaller hydraulically-operated drop-test rigs are provided in the test-house. The larger of these, covering a falling-weight range from 3,000 lb. to 18,000 lb., is of the swinging-frame type similar in principle to the large rigs already described. When necessary, the drop is " assisted " by pulling down the frame with calibrated " Bungee " cords (braided elastic cords). The smaller rig is of the guillotine type, i.e., it comprises an upright frame, to which the undercarriage is attached, sliding between vertical columns. Two loading ranges are available from 300 lb. to 2,000 lb., and from 2,000 lb. to 8,000 lb. In this rig, an aircraft bomb-release forms the quick-release mechanism.

For recording the movements and accelerations occurring on impact during the drop test, two multi-channel Southern Instruments cathode-ray oscillographs, equipped for photographic recording, are employed. This equipment is also used in conjunction with pressure transducers, in functional tests on pumps and other hydraulic gears. Displacements are measured by rheostats and potentiometers, and accelerations by capacity-type accelerometers. A mechanism for recording accelerations is also fitted to the undercarriage. Dynamic strain gauging of various parts of the undercarriage is also carried out during the test. By means of a chopping switch it is possible to record up to seven strain-gauge readings on one cathode-ray tube. In spinning-up tests on multiple-wheel bogies, a high-speed cine camera, operating at 120 frames per second, records the number of revolutions before the wheels come to rest on impact, from which it is possible to deduce the coefficient of friction.

To check the behaviour of nose and tail wheels during taxying, a 30-h.p. Packard motor-car has been adapted to tow a trailer, by strengthening the springs, wheels and chassis. The trailer comprises a rigid frame to which is attached a parallel-motion swing frame, on which the nose or tail-wheel unit is mounted so that it can move up or down, but not sideways, relative to the frame. The trailer can be attached to outriggers extending from the Packard chassis. By this means it is possible to check the behaviour of castoring wheels and to assess the wear and tear on the self-centering cams, the shock absorbers, and the tyres, over rough roads and fields. The trailer is equipped with a bar spring and hydraulic cylinder, communicating with a U-tube inside the car which indicates deflection of the spring, thus enabling the friction drag to be gauged.

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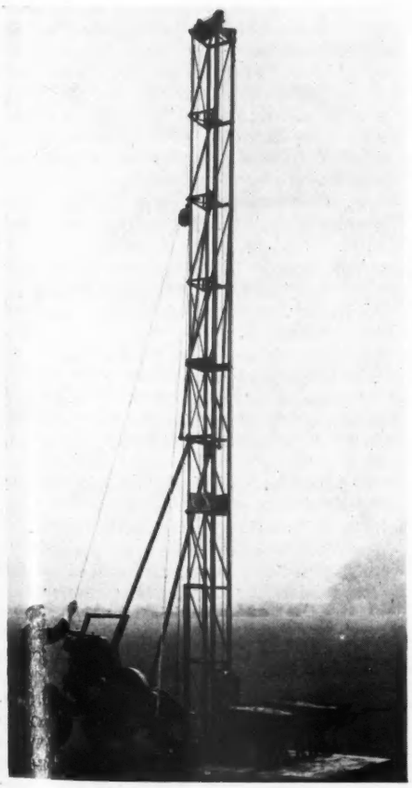


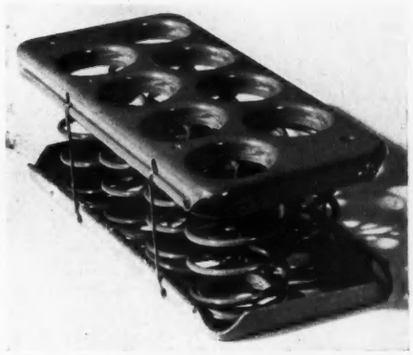
This Mobile Hoist has been designed to lift two Loaded Barrows and can be extended to a Height of 100 ft.

MOBILE HOIST

The hoist illustrated on this page has been designed so that it can be handled and operated by one man. It has a load capacity of 10 cwt. and is driven by a Petter 5-h.p. air-cooled Diesel engine or by a four-stroke petrol engine of the same power ; a smaller model is fitted with a Villiers Mk. 40 4½-h.p. air-cooled petrol engine. For greater adaptability, the winch can be quickly removed from the mobile hoist for independent use.

The all-welded framed tower can support two loaded barrows at its full height of 21 ft., the hoist being made stable by the four screw-jack feet fitted to the base frame. For low working headroom, the top half of the tower can be dismantled so that the hoist has a full lift of only 11 ft. For higher lifts, the tower can be fitted with 11-ft. extensions, increasing the height up to 100 ft. Safety devices are fitted to prevent overwinding. For manhandling the hoist from the horizontal into the upright position, or vice versa, the hoist has been balanced so that, with the rear jacks raised, one man is able to turn it about the segmental skids that can be seen at the back of the base frame. When lowered, the tower rests on a shock-absorbing saddle which helps to prevent the tower from being damaged. For transport on a lorry, the front feet can be folded under the chassis, and, on a short lorry, the tower can be divided.

The hoist is made by A.C.E. Machinery, Limited, Porden-road, Brixton, London, S.W.2, and for shipping purposes it can be packed in two parts: a case, 7 ft. by 5 ft. 6 in. by 5 ft., of gross weight between 13 and 14 cwt. according to the model, and a crate, 13 ft. 6 in. by 2 ft. 7 in. by 1 ft. 9 in., weighing 4 cwt.



The Shock-Absorbing Metpak Unit : Eight Compression Springs between Two Pressed Plates

An Outer Container fitted with Double Metpak Units to Receive an Inner Container

PACKING DELICATE EQUIPMENT

A Special Shock Absorber

To protect expensive and delicate equipment from the shocks and jars of transport, it is necessary to provide some form of resilient packing. For this purpose, Brayhead Springs, Limited, Full View Works, Ascot, Berkshire, have developed a spring unit known as a Metpak. It consists of eight compression springs held between two plates, and may be used either singly or in tiers of two or three where heavier shocks are anticipated.

The units are mounted inside the packing case as shown in the illustration, where they are used in pairs. The equipment they support can then either rest directly on them or be enclosed in a case which in turn rests on the units. It is stated that most electronic equipment can be rendered useless, either through actual damage or being put out of adjustment, by shocks having a force of 70*g* or over. A single Metpak unit will reduce the deceleration force of 10 lb. of equipment dropped from 54 in. to this value. As it is considered that a drop of more than 24 in. is exceptional in this country, this would be adequate protection. Resonance is eliminated and the overall size of the packing case is minimised.

The Graphite-Loaded Plastic Bearings in this Conveyor Roller do not Require Lubrication. The Roller itself is of Plastic Construction and is therefore Light in Weight.

PLASTIC BEARINGS REQUIRING NO LUBRICATION

A Fireproof Conveyor Roller

The range of plastics now available has made possible the development of a conveyor roller constructed almost entirely of plastic materials. Known as the MacCarthy-White plastic conveyor roller, it has been designed primarily to eliminate the risk of fire in coal mines.

Unlike existing types of steel and cast-iron rollers, the plastic roller does not require lubrication and, therefore, carries neither oil nor grease which could contribute to a fire. Furthermore, the plastic materials themselves will not support combustion. It is not possible for any obstruction, such as a stone or piece of coal, to rub the surface of the roller until sufficient heat is generated to initiate a fire. The lightness of the plastic roller appreciably reduces the total weight of conveyor sections. The inertia of the rotating part is small, so easing starting, and wear on the belt due to intermittent contact with the roller is reduced.

The MacCarthy-White roller, which is hollow, is constructed of an envelope of a plastic material reinforced with glass fibre, and having moulded-plastic end caps each housing a graphite-loaded plastic bearing and dust seal. It is made by the Mining Division of White's Marine Engineering Company, Limited, Hebburn-on-Tyne.

SAVING TIME ON A MAIN ASSEMBLY LINE

PRIOR WORK ON SUB-ASSEMBLIES

The time taken for each stage of work on a main assembly line can be reduced to a minimum by preparing some of the sub-assemblies at places in the shop away from the main assembly line. These sub-assemblies can then be brought over at the appropriate times and fitted up very quickly. Interference with other work which may be proceeding is also minimised.

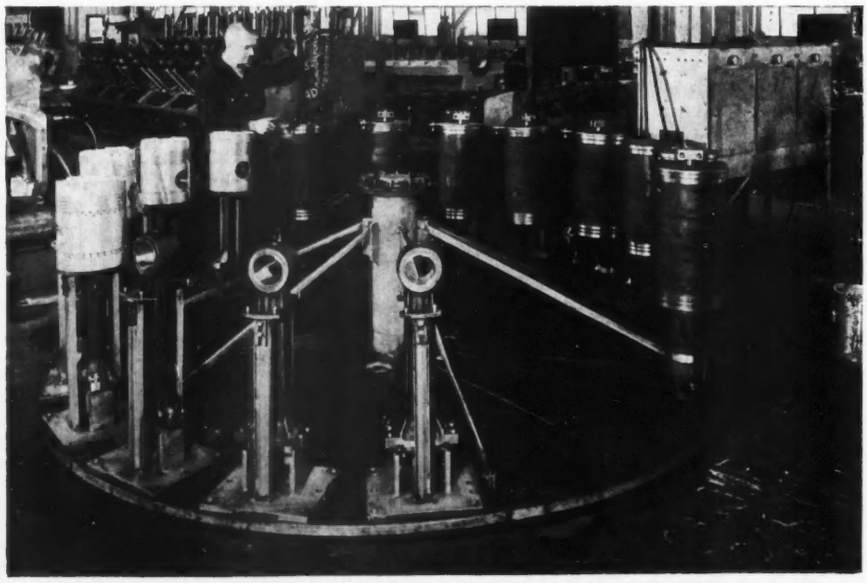
At the Stockport factory of Mirrlees, Bickerton and Day, Limited, this principle has been applied successfully to the assembly of pistons, connecting rods and cylinder liners for the firm's J-type V-form Diesel engines. These engines have a bore of 9¾ in. and a stroke of 10½ in.

When the engine is serviced in the field the pistons and connecting rods are removed and replaced through the crankcase doors of the cylinder housing. This manner of entry is too slow for assembly-line building; it also interferes with other fitting operations going on at the same time. Like most modern high-speed V-form engines, the Mirrlees J engine has large diameter crankpins, and the big-end of the short, stiff connecting rod will not pass through the cylinder liner. This fact prevents the fitting of the piston and rod assembly from the top of the cylinder housing when the liners are in place. An obvious development, therefore, was to fit up the piston, connecting rod and liner as one unit and to lower the unit, complete with sealing rings and gasket, into the housing from the top.

The cylinder-assembly sets are made up at the specially-equipped sub-assembly point shown below, which produces them in engine sets of 8, 12 or 16, according to the sizes of engines going through. As the largest JV engine has 16 cylinders, the sub-assembly point has this number of floor-mounted fixtures, which make it easier to prepare the cylinder sets for pressure testing the cylinder housing.

The gudgeon pin of the JV piston can be fitted only if the temperature of the piston is 150 deg. F. or more. The pin is not fully floating until the piston temperature rises beyond this figure soon after the engine is started up. By this means the working clearances are held to a minimum, thus helping to reduce engine noise and shock loading on the piston. At the sub-assembly point, therefore, the pistons are heated in a thermostatically-controlled electric oven until they are required on the assembly fixtures. By this time the connecting rods have been loaded into the fixtures which locate the rods at the top and bottom, as shown below. The fixture also locates the piston so that the gudgeon pin is easily fitted and secured by its circlips. The piston rings, already checked for gap clearance, are fitted on to the piston, which is then sprayed with a graphite-oil mixture to lubricate the moving parts during the first revolutions of the engine.

The Complete Piston, Connecting Rod and Cylinder Liner Assembly is Lowered without Delay into the Cylinder Housing



Circular Jig on which the Piston, Connecting Rod and Cylinder Liner are Pre-assembled. The Piston is Heated in an Oven to Ensure Clearance for the Gudgeon Pin.

Cylinder liners coming off a 1,500 lb. per square inch static pressure test are led to the assembly point along a roller track, and each has a smoothly chamfered cast-iron ring clamped to its lower end. This is for guiding the piston rings into the liner because at this stage a liner is lowered over each piston assembly. After this, the guide rings are dropped off the liner, which now rests on two spacing blocks located in the big-end bolt holes.

The whole assembly is clamped together by a circular plate fitted over the top end of the liner and pulled down by screwing four set-screws into corresponding holes provided for this purpose in the piston crown. The cylinder set is now complete except for two rubber water-sealing rings and a copper gasket, which are fitted to the liner after the assembly is lifted from the fixture.

The sub-assembly point feeds directly on to the first station of the main assembly line, where the cylinder housing is fitted with cylinder-head studs tightened to a controlled torque by pneumatic stud-driving equipment. The cylinder banks of the JV engine housing lie at 22½ deg. to the vertical, and a section of the assembly

track is made to swivel through this angle on either side of the horizontal, so that when the cylinder assembly sets are ready to be lowered into the housing, as shown in the illustration the cylinder centre-lines can then be swung to the vertical position, thus ensuring easier and more certain fitting of the liner, its rubber sealing rings and copper gasket.

As previously mentioned, the method of making up the cylinder assembly sets helps in the pressure testing of the cylinder-housing water jacket. The circular clamping plate on the top of the liner holds, on its underside, two rubber washers which blank off the water-outlet holes in the cylinder housing. When the cylinder sets are fitted into the housing, each assembly is held down by two swivelling claw clamps attached to the circular plate. With the water-outlet holes blanked off and the inlets fitted with quickly-clamped hose connections, the water jacket is proved with water at 60 lb. per square inch. The cylinder housing is then moved to the next station, where the clamps, circular plate and spacing blocks are removed.

ULTRA-SENSITIVE MECHANICAL COMPARATOR

GRADUATIONS IN 0·000001 IN.

A mechanically-operated comparator which has a magnification of 200,000 is undoubtedly an instrument for a standards room only, yet such an instrument is a production model from the range of "Mikrokators" made by C. E. Johansson, Limited, Southfields-road, Dunstable, Bedfordshire.

Experimental models have been made to give direct magnifications of 500,000, and by using a light-beam indicator, 35 in. in length, stable amplifications of 12,000,000 to 1 have been achieved. Fig. 3, herewith, shows two standard instruments mounted on a common pillar for checking the dimensions of the outer race of a ball bearing. The sectional drawing, Fig. 2, shows the main features of the mechanism and Fig. 1 shows the ingenious magnifying mechanism. A delicate metal strip is twisted in such a way that one half of its length forms a left-handed helix and the other half forms a right-handed helix. It is manufactured so that it remains in this state, with no tendency to go back to a flat condition so long as no force is applied to it. However, when one end is fixed and the other is pulled axially away from it, the centre of the strip untwists. It thus behaves like the loop of string with a button threaded on at the centre that boys play with : by pulling the ends of the loop or strip apart the centre in each case rotates many times, although the axial movement is small.

Fig. 2 shows how the movement of the vertical plunger *a* (the measuring point at the bottom of which usually has a hardened ball fitted) is transmitted through a spring knee-lever *b* to the twisted strip. A spring controls the movement of the plunger. The relationship between the rotation of the needle which is fixed to the centre of the strip, the elongation of the strip, and the force producing that elongation depends on the physical dimensions of the strip, and the properties of the material from which it is made. Sometimes the strip is perforated to give the required result and to prevent the material from being overstressed.

In an instrument with a magnification of 5,200, the strip used is 0·06 mm. by 0·0025 mm. and 40 mm. long, without perforations, and is twisted 4,000 deg. (11 turns) ; the indicating needle is 30 mm. long. If the amplification ratio of a spring knee-lever is added to that of the strip, this magnification can be increased 10 times. Higher magnifications are obtained by introducing an additional lever into the system, the lever being mounted on springs or on a spring cross.

With the strip mentioned above the force required to give a 90-deg. movement of the needle is about 0·3 grammes, but this can be reduced to 0·03 grammes by balancing the initial tension of the strip with a spring knee. The needle used as a pointer must be as light as possible, so that any jars which the instrument may receive shall not cause damage to the strip. Also, the lighter the needle, the lower will be the natural periodicity and the greater the damping effect of the air. Additional damping is provided by arranging for the strip to rotate in a drop of oil contained in a short length of split tubing close to the pointer ; this has been found to be very effective. The needle used in the Mikrokator instruments is made of tapered glass tubing. The dimensions vary, but average sizes are 0·0024 in. at the large end and 0·0012 in. at the tip. In order to make the pointer more easily visible, a tip of duralumin is fitted. Such a piece of glass has great flexibility and can withstand quite severe shocks ; it can be bent into a semi-circle of ⅜-in. radius and will return to its original form when released.

A series of the instruments is made, the least sensitive having a measuring range of ± 0·003 in. with graduations every 0·0001 in. and the most sensitive a range of ± 0·0001 in., the graduations being 0·000002 in. Special Mikrokators have been made with a range of ± 0·00002 in. and graduations for each 0·000001 in. The measuring pressure of the standard models is about 250 grammes but this can be varied from 50 to 1,000 grammes for special applications. Where the materials are soft or liable to be deformed, as in the case of thin wires, instruments have been made with a pressure as low as 0·2 grammes. The standard measuring point is a 5-mm. Hultgren ball which is extremely hard, but tungsten carbide, diamond or other materials can be used if needed. Two adjustable tolerance pointers are mounted on the scale, coloured black to show clearly against the yellow background.

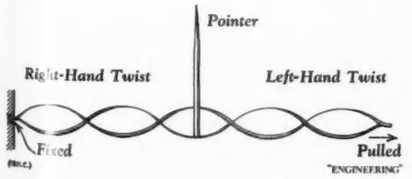


Fig. 1 The Twisted Strip which Gives Very High Magnifications of Movement. A Small Pull on One End causes a Large Rotary Movement at the Centre where the Needle is Fixed.

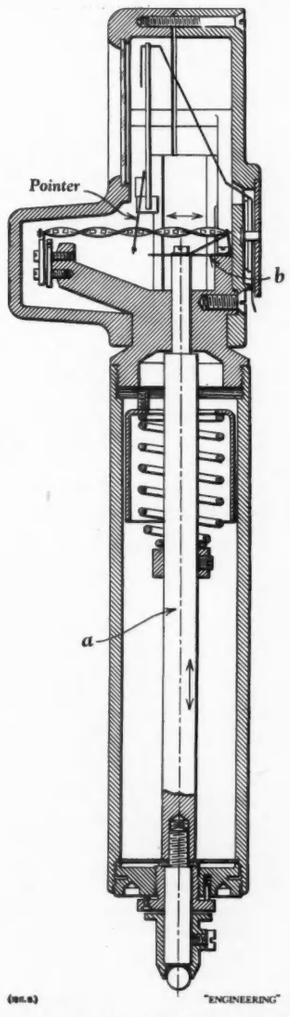


Fig. 2 Vertical Section through Instrument

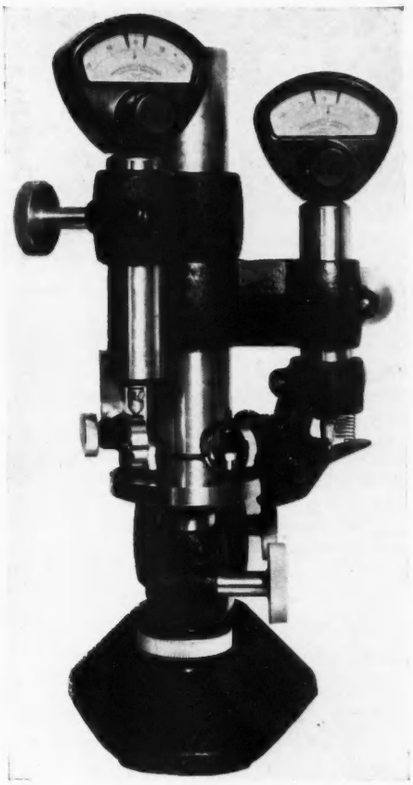


Fig. 3 Two Mikrokators for Checking Outer Race of Ball Bearing

COLD FORGING OF COMPONENTS FROM WIRE AND STRIP

AN ADAPTABLE GEARED PRESS

A GEARED press made by Taylor and Challen, Limited, Derwent Works, Birmingham, 19, is capable of cold forging a wide variety of components from wire and strip. It produces 40 pieces a minute and exerts a maximum pressure of 120 tons at the bottom of the stroke. The wire or strip is fed automatically from a coil-holder, each movement—and therefore each component—being any length up to 9 in. The machine shown on this page has been installed at the works of Henry Squire and Sons, Limited, New Invention, Willenhall, Staffordshire, where it is used for forging the components illustrated below. These are padlock hasps (top centre), the first production stage of which it performs, and the two handles of the Squire patent can-opener, though of course the press can be fitted with dies and set up for any shape within its scope.

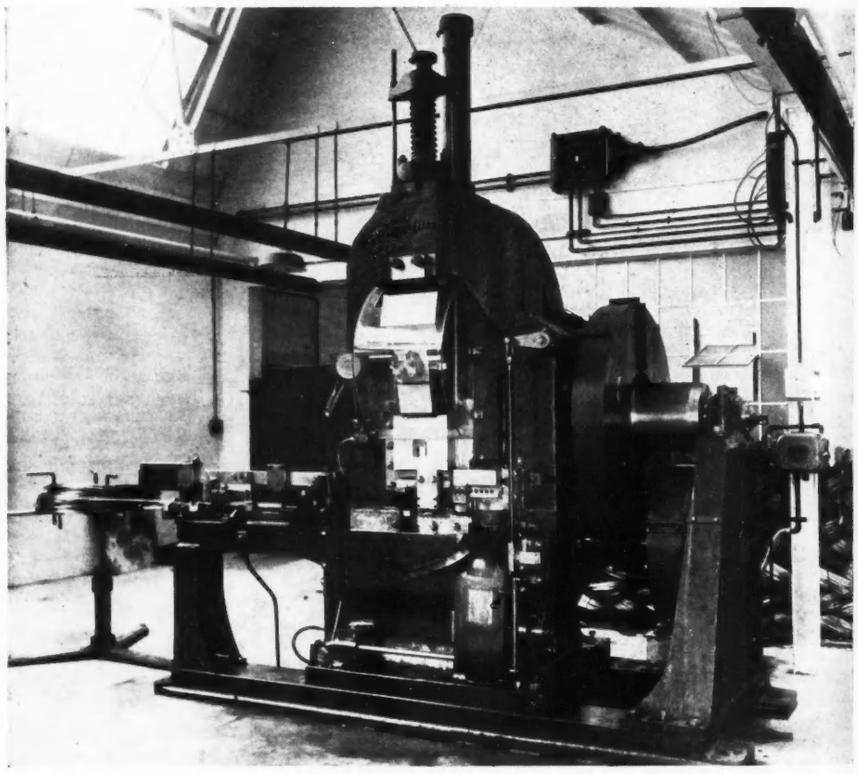
The padlock hasp is also shown in its straight form, in which it has two flattened portions, one at each end. The thicker of these is subsequently trimmed and pierced to enable it to pass into the lock body and there engage with the lock bolt, while the thinner end is subjected to a bending operation to form the hasp hinge. The hasp is then bent into its familiar U-shape. The Taylor and Challen press is used to produce, by cold forging, a flat of two thicknesses in a length of wire fed from a coil, and to shear the flattened portion approximately in the middle, so producing a straight component with a flat of the required size and thickness at each end, ready for subsequent trimming, piercing and bending.

In the case of the can-opener handles, one is formed from strip, and the other from wire. That formed from wire (shown immediately below the can-opener) involves a fairly heavy cold-forging operation to produce a stepped flat, with two riveting stubs extruded from it. This shape is produced in the press in a single stroke, and separate tools in the same press then shear the component from the wire. The other can-opener handle, shown at the bottom of the picture, is formed from strip. It is given the form of a shallow channel along part of its length, for stiffening purposes, and simultaneously letter stamps mounted in the tools mark the using instructions on one side of the handle, and the makers' name and address on the other. The shearing of the component from the strip is done with a combination tool, which not only separates the component and trims the ends, but also pierces the two holes and the half-hole visible in the illustration, and forms the hook shape at the end. These are two of the operations for which the press was designed ; it is obvious that by the use of suitable tooling a large variety of components of a like nature can be made.

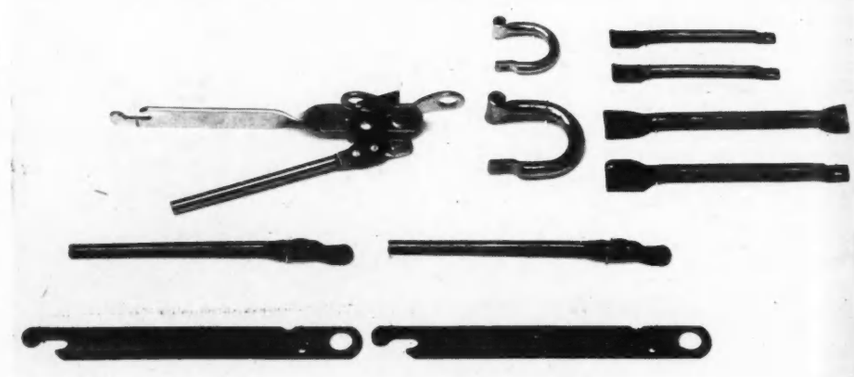
CONTINUOUS FEED

The work done by the press is very similar to that carried out in minting coins, and the press is, in fact, based on the manufacturers' coining press, the work of cold forging being performed by toggle-operated tools. To allow for a continuous feed from a coil of wire or strip, the tools are overhung, instead of being within the frame, as is the case with a coining press, and a subsidiary slide is provided for shearing the components from the wire or strip after forming. The press is of heavy cast-iron construction, with two box-section sole-plates supporting the main frame, the outboard bearings for the crankshaft and countershaft, and the feed apparatus. A 10-h.p. electric motor, carried in the usual manner on slides behind the press, and running at 720 r.p.m., drives, through six rubber V-belts, a countershaft carrying a spur pinion. The V-belt pulley on the countershaft is cast with a heavy rim to act as a flywheel. The spur-pinion on the countershaft gears into a spur-wheel on the crankshaft, which rotates at 40 r.p.m. Incorporated in the latter gearwheel is one of the manufacturers' standard key clutches, which is not, however, arranged for single-stroking.

Since the press is designed for continuous running, the control of the clutch is by means of a hand-lever, visible at the front of the main housing. To start the press, the hand-lever is lifted, thus allowing the clutch key to engage. The control hand-lever is held in the running position by a trip lever ; movement of this trip releases the control hand-lever, brings the clutch cam plate out, and so withdraws the key. An externally-contracting band brake is mounted on the crankshaft, and interconnected with the control hand-lever, to bring the press quickly to a stop when the clutch is disengaged. All



The Wire or Strip is fed automatically from the Coil-Holder on the left. Rate of Production is 40 pieces per minute, and a length of up to 9 in. can be Pressed at each Stroke



Typical Cold Forged Components : Padlock Hasps (Top Right) and two Kinds of Handles for the Patent Can-Opener (Top Left)

normal stopping and starting of the press is controlled by the hand-lever; an emergency stop push-button controlling the motor is provided for use in case of necessity.

1½ IN. STROKE OF MAIN SLIDE

The crankshaft operates a short connecting rod, which in turn works the toggle lever controlling the main slide. The combination of gearing and toggle gives a pressure at the bottom of the stroke of 120 tons. The stroke of the main slide is 1½ in., and the "daylight" can be adjusted by means of four screws mounted in the toggle tumbler and rotated simultaneously by a ratchet and hand-lever. An adjustment of ½ in. is obtainable in this way. The main slide is carried on V-guides, one of which is solid with the body of the press, while the other is adjustable for wear by means of wedges. T-slots are provided for carrying the top tool in the main slide, and a machined ledge on the press body accommodates the bottom tool. In accordance with modern practice the main slide is counterbalanced by the helical spring visible at the top of the press body in the illustration, and the toggle lever is also counterbalanced by a second spring, which can be seen behind the main-slide spring.

The subsidiary slide, used for shearing off components after forming, is towards the right-hand side of the machine in the illustration. It is operated by an eccentric on the crankshaft, which is connected to a crank at the bottom of the main frame, and gives the slide a stroke of ⅜ in. A right and left-hand screw with locking nuts, incorporated in the connection between the crank and the slide, enables the initial setting of the top tool to be made. The position of the top tool is also adjustable laterally, to cater for varying amounts of "growth" in the length of a component as it is formed by the main tools.

The wire or strip is taken from a coil-holder, and is led through straightening rollers to a pair of positive feed grippers. Two sets of straightening rollers are provided, one with the spindles vertical and the other with the spindles horizontal. Each roller is individually adjustable by means of screws and lock-nuts, and cam-operated quick-release gear is provided on each set of rollers to enable the feeding of the end of a fresh coil of wire or strip to be carried out quickly. From the straightening rollers the wire or strip passes through a short guide and into the positive feed grippers, which are arranged to close, draw the wire or strip forward the correct distance, release it, and then return to the starting position while the press makes its working stroke. The grippers are reciprocated by a sliding link motion, which gives infinitely-variable adjustment of feed from zero to 9 in. To drive the link motion, a machine-cut bevel gear is mounted on the crankshaft, and this engages with an identical gear of the shaft which carries the disc and roller for working in the slotted link. The bevel gears are totally enclosed.

In operation the press works continuously at 40 strokes per minute, the only stops being those to replace the coil of wire or strip, and these stops are of short duration. When a coil is practically exhausted, the press is stopped, and a small portable electric welding plant is used to join the end of a new coil to the end of the old one. The press is then re-started, and the operator watches the movement of the weld towards the tools. One component will be produced with the weld in some part of its length; it is this for which the operator watches after re-starting the press. It is caught as it leaves the discharge chute at the front of the press, and thrown aside for scrap. By the adoption of this method of feeding in the new coils of wire or strip, considerable time is saved, and the total scrap produced is normally one component per coil of material.

The press is provided with gun-metal liners to all bearings, and is lubricated by a Wakefield mechanical lubricator, mounted at the rear and chain driven from the crankshaft. The lubricator is divided into two sections. One, the smaller of the two, provides special high-pressure oil for the steelings of the toggle mechanism; the other section provides normal lubricant for all the rotating parts.

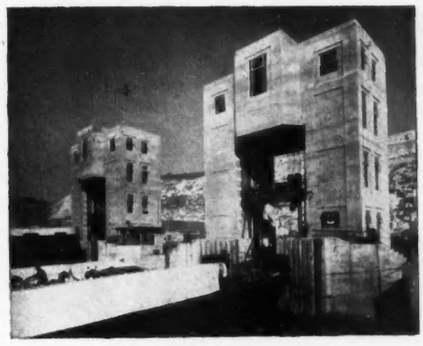


Fig. 1 Car Ferries berthed at Terminal

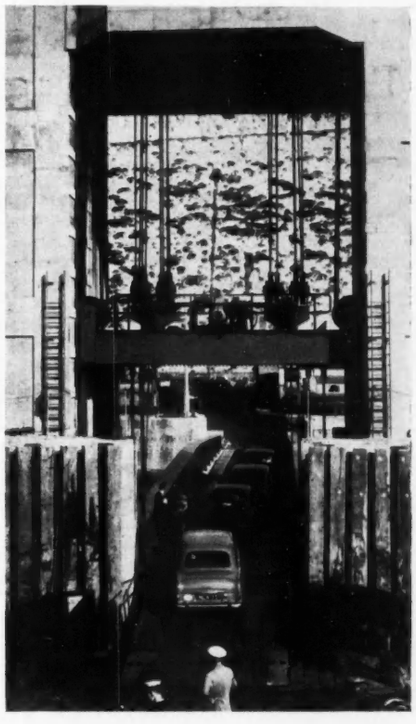


Fig. 2 Bridge Span and subsidiary Link-span suspended from Cross-girder. The Winch Gear raises or lowers the Bridge Span and Link-span to suit changes in level of the Car Ferry

WINCH GEAR FOR CAR-FERRY BRIDGE SPANS

AUTOMATIC CONTROL TO SUIT TIDAL LEVEL

Two bridge spans which link the berthed car-ferries to the shore at Dover are hinged at the landward ends and are raised and lowered automatically at the seaward ends to suit the rise and fall of the vessels with the tide and with variations in deck loading.

The ferries are berthed with their sterns to the portal structures, as shown in Fig. 1. One of the bridge spans can be seen in Fig. 2, which is a view taken from the ferry. This picture also shows the short "link-span" – hinged to the seaward end of the bridge, and resting on the deck of the ferry – which is allowed to move freely to the extent of 3 in. vertically at its deck end. When the movement exceeds 3 in., due to the effect of the tide or the loading of the vessel, the main bridge span is automatically raised (or lowered) by winch gear housed in the upper part of the portal structure. Fig. 2 shows the cross-beam which is coupled to the end of the bridge span and is suspended on the winch ropes for this purpose. The small winch carried on the centre of the girder operates the link-span.

The bridges are 140 ft. long and weigh 240 tons each. Vessels can be loaded at all states of the tide and, even with extreme tides, loading can proceed provided that the deck is between 6 ft. and 18 ft. 6 in. above water level. The range of ordinary spring tides at Dover is 18 ft. 9 in., but for the purpose of design the range has been taken as 22 ft. The maximum movement of the seaward end of a bridge is therefore 34 ft. 6 in., so that cars can be loaded on to the lower deck of the ferry at the lowest of low tides, and on to the top deck at the highest.

The dead load of the bridge is balanced by two counterweights in the wings of each portal. The live load is carried by the main winch. Both the winches for the main bridge and for the link-span are operated from a control desk inside the cabin situated between the two portals (Fig. 1). The main bridge winch is driven by a 15-h.p. slip-ring induction motor running at 1,420 r.p.m. Connected directly in tandem with this motor, but not normally in service, is a second and similar motor which can be brought into emergency operation by a change-over switch connecting the control gear of one motor to that of the other. The motors drive the winch through gearing providing three stages of speed reduction to 4, 1 and 0·33 r.p.m., the last figure being the speed of the winch drum used for

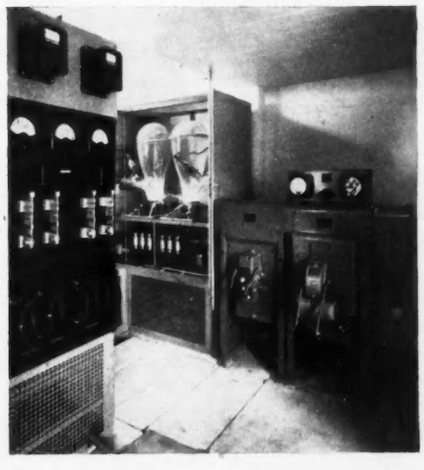


Fig. 3 Medium-voltage Switchgear, Rectifier Unit and Switchboard for Ship-to-Shore Supply

raising and lowering the bridge. The link-span winch is driven by a 5-h.p. slip-ring motor working through a worm-gear reduction unit.

The control mechanism is designed to allow manual control as the bridge is being brought into its working position. When the bridge is approximately in its final position, the link-span is lowered on to the deck and the change made from manual to automatic control. If, at the moment the link-span touches the ferry deck, the slope of the link-span is incorrect, the automatic control initiates the operation of the bridge winch to raise or lower the bridge until the link-span angle is correct. The automatic control uses limit switches housed in the end of the bridge span and actuated by an arm which protrudes below the link-span. Variations in the level of the ferry deck, and therefore in the angle of the link-span, are thereby translated into an appropriate movement of the bridge which re-establishes the correct alignment.

POWER SUPPLIES FROM ELECTRIC SUBSTATION

To provide electric power for the bridge machinery and for general power, lighting and heating requirements, a substation was installed to take an incoming supply from the South Eastern Electricity Board at 6·6 kV and to step it down to 415/240 volts, three-phase, four-wire. In addition, the substation also contains two banks of mercury-arc rectifiers to provide a direct-current supply between shore and ship for the ferries when berthed. The substation plant consists of a 6·6-kV three-unit Crompton Parkinson switchboard for controlling the incoming feeder ; the primary of a 475-kVA 6,600/415/240-volt transformer ; and the primary of a mercury-arc rectifier transformer. Each unit is equipped with an oil circuit-breaker of 150-MVA breaking capacity and a normal current rating of 600 amperes. The transformer output is controlled by one 800-ampere unit of a two-unit " Klad " 415/240-volt four-wire switchboard, the second unit of which is rated at 400 amperes and controls the supply to five switch-fuse distribution boards for separate services to the buildings, the jetties, a crane and the two bridge portals.

A three-phase cable has been installed to the end of the west jetty to meet future requirements for an alternating-current supply to berthed vessels. Normally, the mains supply is used for the motors operating the bridge machinery but, in an emergency, an alternative supply from a stand-by 37·5-kVA Diesel-engine alternator set is available. Changeover from one supply to the other can be effected immediately by a selector switch in the control cabin.

The rectifier transformer supplies four glass-bulb units giving an output of 200 kW at 220/230 volts. The bulbs are mounted in pairs in sheet-steel cubicles provided with automatically-controlled fan cooling. The rectifier units are equipped with grid control gear to give a rising output-voltage characteristic from 220 volts at light load to 230 volts at full load. The rectifier output is fitted to a direct-current switchboard which controls two outgoing feeders to the jetties. This switchboard, and two of the transformers, are shown in Fig. 3, on page 25. The feeders are arranged to provide alternative 50-kW power sockets for each of the two loading berths and similarly for each of two lay-by berths.

The terminal was designed by the chief engineer to the Dover Harbour Board, Mr. J. W. Sutton, O.B.E., M.I.C.E., M.I.Mech.E. M. B. Wild and Company, Limited, Argyle-street, Nechells, Birmingham, were the main contractors for the bridge-hoisting machinery, which was erected by the Brown and Aitken Engineering Company, Limited, 50, Pall Mall, London, S.W.1. The general arrangement of the terminal was described in a previous article (page 55, July 10, 1953).

The main electrical installation was designed and carried out by Crompton Parkinson, Limited, Crompton House, Aldwych, London, W.C.2. The contract included the supply and installation of high-voltage and medium-voltage switchgear, power transformers, cables, machinery drives and controls. Allen West and Company, Limited, Lewes-road, Brighton, 7, designed and manufactured the control gear.

Among the firms responsible for supplying equipment were the following : David Brown-Jackson, Limited, Hampson-street, Manchester, and Alfred Wiseman and Company, Limited, Glover-street, Birmingham, 9—reduction gearing ; Nevelin Electric Company, Limited, Purley-way, Croydon—mercury-arc rectifier units ; and Petbow, Limited, Richborough, Sandwich, Kent—stand-by electric alternator. Palmers Hebburn Company, Limited, Hebburn, Co. Durham, constructed the steel bridges and link-spans and Mears Brothers (Contractors), Limited, 154, Sydenham-road, London, S.E.26, were the general civil-engineering contractors.

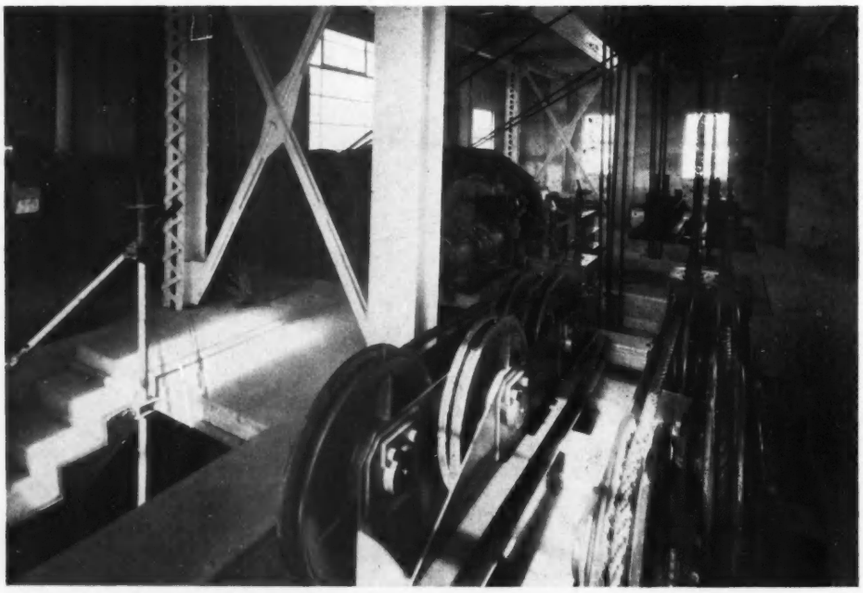


Fig. 4 Main Winches housed in upper part of Portal Structure

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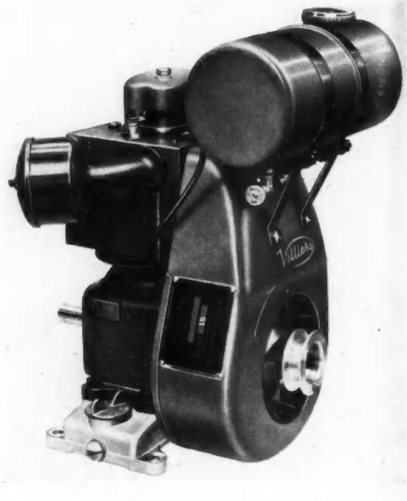

1·1-H.P. FOUR-STROKE PETROL ENGINE

The Villiers Engineering Company, Limited, Marston-road, Wolverhampton, have added a new engine to their range of lightweight petrol engines—the Villiers Mark 15. It is a single-cylinder air-cooled four-stroke engine, with overhead valves, capable of developing 1·1 brake horse-power at 1,500 r.p.m., or 1·95 brake horse-power at 2,800 r.p.m. The bore and stroke are 63 mm. and 47 mm., respectively, and the cubic capacity is 147 c.c.

The cylinder is of cast iron, heavily ribbed for cooling, and is cast integrally with the crankcase. A detachable cast-iron cylinder head, similarly ribbed, carries the overhead valve gear, which is totally enclosed and automatically lubricated. The piston is of aluminium alloy, with three compression rings and one slotted oil ring, and the connecting rod is of forged high-tensile aluminium alloy. Replaceable white-metal bearing liners are fitted to the connecting rod. A hollow gudgeon pin, hardened and ground, is secured in the piston by Circlips. The crankshaft, of forged steel, is mounted in ball bearings, and carries at one end a flywheel magneto and a fan for cooling purposes. Air from the fan is delivered to the cylinder and cylinder head by a sheet-steel cowling. At the opposite end of the crankshaft is the power take-off shaft, $\frac{3}{4}$ in. in diameter and $2\frac{1}{16}$ in. long, with a keyway. The carburettor is of Villiers design and manufacture. The engine is splash-lubricated, a cast oil reservoir forming the base for mounting purposes. It is provided with four lugs for bolting down. An exhaust silencer, oil-bath air cleaner, and a half-gallon petrol tank are fitted as standard. The speed of the engine is controlled by a totally-enclosed adjustable governor.

This engine was exhibited for the first time at the recent Smithfield Agricultural Show and Machinery Exhibition, held at Earls Court, London.

Fig. 1 General View of Machine, showing Duplicate Ovens

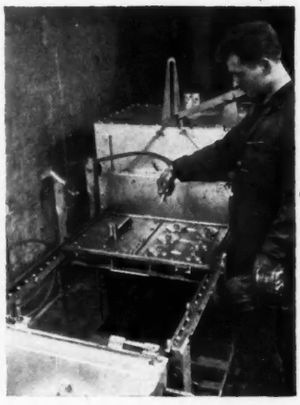

Fig. 2 The Pattern Plate is cleaned by Compressed Air

Fig. 3 Plate is reversed over the Dump Box

SHELL MOULDING MACHINE

SIMPLE DESIGN PRODUCES 40 MOULDS AN HOUR

Where many small parts of fairly intricate shape and yet with good finish are required, the practice of shell moulding offers many advantages to the manufacturer. Limits can be maintained closely and machining operations can be reduced if not eliminated, in addition to the direct saving in the foundry.

Textile machinery, particularly spinning machines, requires a great number of small components, and the finish of these must be good to avoid damage to the yarn and cloth. Consequently, Fairbairn Lawson Combe Barbour, Limited, Leeds, investigated the possibilities of shell-moulding and have now produced a machine which they call the Shelmolda. This was primarily made for their own production lines, but is also being offered for sale. Simplicity and low cost are probably its two most outstanding attributes. One model is shown in Fig. 1. At each end are the curing ovens and in the centre the dump-box. The duplication allows a continuous cycle to be operated. With the machine shown, a production rate of 40 shells an hour can be easily maintained and higher rates have been achieved ; the curing-time is the chief controlling factor. Overall dimensions are 12 ft. 6 in. by 3 ft. 6 in. by 5 ft. high, and the pattern plate is 24 in. by 16 in. by $\frac{5}{8}$ in., allowing a maximum depth of pattern of 4 in. The ejectors have a $1\frac{1}{2}$-in. lift.

Once the pattern-plates have been heated, the cycle of operations becomes continuous, for the plates do not have time to become cold during the process. The ovens are gas-fired and are equipped with thermostatic control. The door is lifted by depressing a pedal and there is a hand-controlled damper in the chimney. The heated plate is blown clean with compressed air, as shown in Fig. 2, above, and then sprayed with a silicone grease. Beneath the pattern-plate in Fig. 2 is the plate for lifting the ejector pins, which are spring loaded. The lifting is also foot-operated and there are guides on either side to hold the plate down while the shell is being ejected. After spraying, the plate is slid along to the dump-box so that the half-hinges are engaged. The plate is swung over on the hinges and clamped in place on the box.

Inversion of the dump-box may either be by hand or by using a pneumatic cylinder. It can hold 2 cwt. of sand mix, and there should always be enough present to cover the highest points of the pattern with a 4-in. layer. Investment time is usually about 15 seconds, and should be fairly closely controlled in order to give consistent shells. When the dump-box has been turned back again and the pattern-plate swung back, any thin places of the shell can be made up by scattering a handful of mix over them. The plate is then slid back into the oven for curing. While the shell is being cured at one end of the machine, the second plate

Fig. 4 Locking the Plate in Position

Fig. 5 The Dump Box is Reversed

Fig. 9 Finally, the Shell is Removed

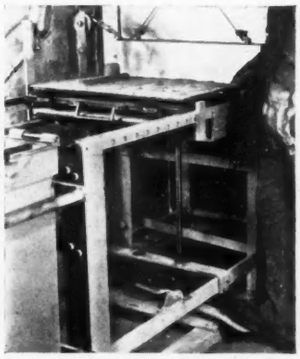

Fig. 8 The Pedal is depressed and the Shell lifted from the Plate

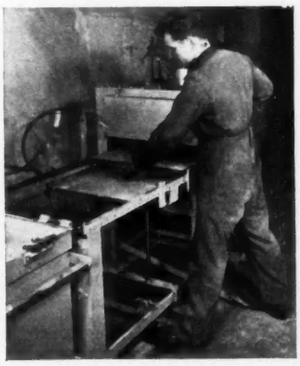

Fig. 7 The Shell is baked in the Oven

Fig. 6 Dump Box is Reversed and Plate raised to show Invested Shell

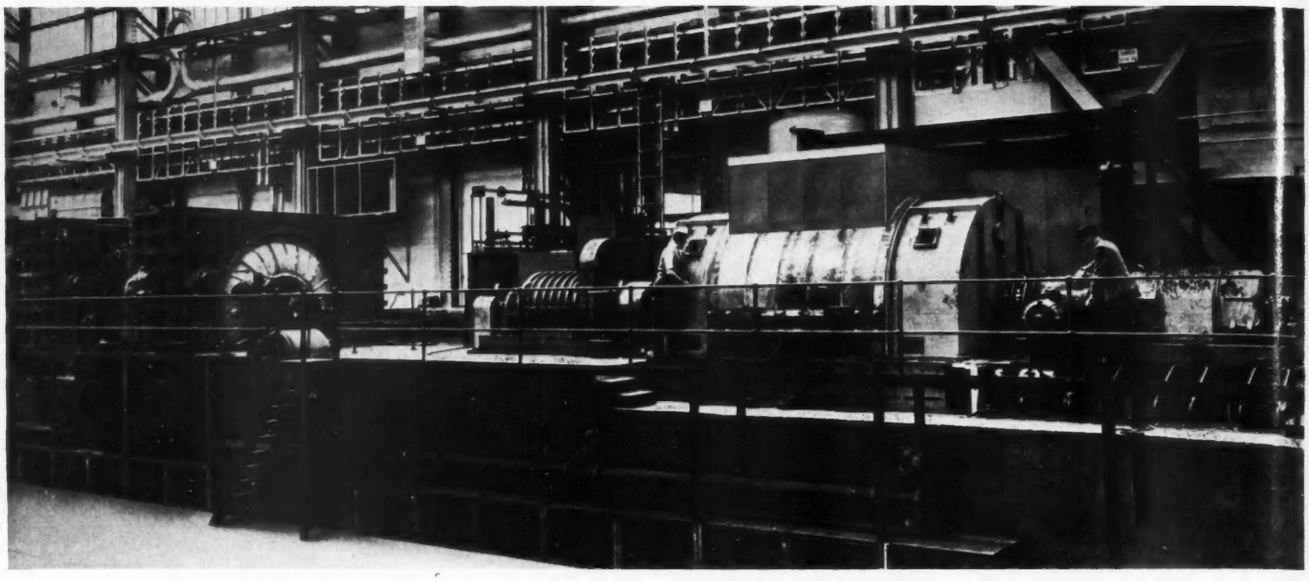

Fig. 1 Test Bed at Witton Works : 30-MW air-cooled Alternator on test and 60-MW hydrogen-cooled Alternator being erected

can be invested and by the time that it has been placed in the second oven for curing, the first will be ready for removal. Normally, a minute should be allowed for curing, but this will vary with oven temperature and the mix used. When the shell is cured, the plate is slid out of the oven and over the ejector mechanism; the shell is then lifted clear by the ejector pins and placed in the storage rack.

The particular pattern-plate in the illustrations has both halves of the shell on it, which means that a complete mould is made at each operation. When a mould is required, the shell is taken from the rack (experience has shown that they are less liable to distortion if stored vertically) and broken at the dividing line. The two halves are then put together, matching being ensured by spigots and holes cast in the shells, and are held by steel U-clamps pushed over the edges. Heavier shells are held by similar clamps but fixed with wooden wedges and not merely by the spring of the metal. The mould is then laid flat on a sand bed with a weight on the centre to hold the top half down. It has been found that this simple system of clamping the shells is quite satisfactory for horizontal pouring, and the runners are arranged for this. Vertical pouring requires elaborate clamping devices to hold the halves together, which do not seem to be justified.

It is claimed that limits are maintained to less than 0·01 in. Thus only grinding and buffing are required subsequently ; the untouched surface will take paint or enamel quite satisfactorily. Fairbairn Lawson Combe Barbour are now using shell-moulding as part of their ordinary practice, and the incorporation of this machine in their production lines would seem to have solved the problem, always present in this process, of handling the heavy, hot pattern plate.

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ROADWAY OVER THE FORTH BRIDGE ?

The Minister of Transport has announced that Sir William Arrol & Co., Ltd., Glasgow, have accepted his invitation to be represented in a consultative capacity on the committee examining the proposals of Sir Bruce White for placing a roadway through the Forth Bridge. The company were the original steelwork contractors for the bridge and have since undertaken the maintenance work.

TESTING LARGE ALTERNATORS

ARTIFICIAL LOADING BY REACTORS

The only practicable method of ensuring that the large alternators now becoming common are capable of performing their rated duties is to subject them to some form of artificial loading. The General Electric Company, Limited, have recently installed equipment of a new design for this purpose at their Witton works. This also permits investigations to be carried out under closely controlled conditions. An important point is that the data thus obtained can quickly be made available to the designer and incorporated in subsequent production.

The plant is installed adjacent to the test-bed in the heavy engineering shop and consists of two reactors, each with a six-limbed core on which the tertiary windings are carried. These windings are arranged so that the current drawn from the alternator under test is practically sinusoidal, the wave form having a harmonic content of only 1½ per cent. The reactors which, as shown in Fig. 2, are situated in the open, are forced-oil cooled, the coolers, which are of the forced-draught type with integral fans, being mounted alongside. They are solidly connected to the alternator under test by tubular copper 'bus-bars with a current-carrying capacity of 6,000 amperes, the insulation being suitable for a working voltage of 30 kV.

Direct-current excitation is obtained from a twelve-phase grid-controlled rectifier of the pumpless steel type. This rectifier, the output voltage of which can be varied to meet the required conditions of excitation, is housed in an internal substation and is supplied from the 11-kV supply through an outdoor transformer. Protective devices are provided to cut-off the excitation of both the alternator and the reactors so as to make the alternating-current circuits dead.

With this arrangement the reactors provide a load, the rated current and voltage of which are at zero power factor. This load can be controlled over a wide range by varying the direct-current excitation of the cores. Without this excitation the reactors only absorb 500 kVA, but when direct-current excited this figure can be smoothly increased up to 100 MVA. Maximum loads of 75 MVA at 11 kV and 22 kV or 37 MVA at 6·6 kV can also be obtained by re-arranging a system of external flexible links.

The alternator is erected on the main test bed in the works. This bed is 133 ft. long by 19 ft. wide and comprises a central platform 8 ft. high, on either side of which is a bed 50 ft. 6 in. long and 6 ft. 3 in. above the shop floor. One machine can therefore be erected or dismantled while a second is on test, as shown in Fig. 1, which illustrates a 30-MW air-cooled machine on test and a 60-MW hydrogen-cooled machine in course of erection. Each of the beds is built so as to form a pit below the machine and is provided with ducts for closed-circuit air-ventilation or hydrogen-cooling. It is arranged to support the stators and rotors of steam-driven alternators with outputs from 12 to 200 MW. The alternator under test is driven by a 3,000-h.p. two-pole induction motor, which also supplies all the losses. This motor is connected to the 11-kV supply through a step-down transformer and two induction regulators (which are housed in the test substation) and is controlled by a remotely operated liquid controller. With this equipment it is possible to run a 60-MW machine up to speed in about five minutes and to shut it down in four minutes. In the case of very large machines additional power can be obtained by coupling two motors in tandem.

Particular attention in the lay-out of the test bed has been given to the lubricating system. Oil for the bearings and the hydrogen seal is supplied from a reservoir with a capacity of 2,500 gallons, which is under an air pressure of 60 lb. per square inch. Both this pressure and the oil flow are maintained by screw-type pumps. These are independently driven by squirrel-cage motors, which are automatically switched over to a separate emergency supply should the main supply fail. If, in turn, this supply should fail, or the pumps break down, the reservoir capacity is sufficient to allow

the largest alternator to be brought to rest.

The heat generated in the alternator and its bearings is dissipated in a closed circuit, the water in which is cooled by forced-draught spray coolers. In the case of hydrogen-cooled alternators, these coolers are built into the machines, but those for air-cooled alternators form a separate unit. Both the oil and water-cooling equipment is installed in the outdoor substation. During tests, the hydrogen supply is manually controlled and checked by a purity meter and pressure gauge. There is also an inclined oil gauge of the U-tube type, which indicates the gas pressure and purity.

All the necessary test and auxiliary instruments are situated in a central control room. These instruments include permanent meters in the driving-motor circuit and ammeters in the circuits of all the essential auxiliaries. The failure of any essential circuit is indicated by alarms. The alternator under test is metered by portable sub-standard instruments, while 48-point and 12-point temperature indicators enable readings to be obtained from the normal embedded temperature detectors and additional temporary thermo-couples.

Facing the control board on which these instruments are mounted is a lubrication panel carrying valves, pressure gauges, sight flow indicators and thermometers. The test beds are connected by screened cables to oscillographs in a separate section, which is complete with a photographic dark room. Records are taken on a six-element electromagnetic oscillograph using a film 120 mm. wide by 320 mm. long. Alternative arrangements permit the use of a continuous film for measuring transients or where records over longer periods are required.

During a recent visit to this plant, one of the machines under test was the third 60-MW 11·8-kV alternator which the General Electric Company has constructed for the Uskmouth station of the British Electricity Authority. This machine, like its two predecessors, is cooled with hydrogen at a pressure of ½ lb. per square inch, the gas being circulated by fans through the windings and then through four coolers. It may be recorded that the two machines now in operation at Uskmouth have shown a heat consumption of 9,027 B.Th.U. per kilowatt-hour at full load on test, a figure which is believed to be the highest recorded for generators of their size working under steam conditions of 900 lb. per square inch and 900 deg. F.

Fig. 2 Outdoor Substation, showing Reactors and Power Transformers

SUPPORTS IN COAL MINES

Steel Replaces Timber

The following table taken from a recent report* indicates the inroads made by steel for use as supports in mining work.

In the upper part it will be observed that the length of roadways in use below ground supported by steel arches has increased from 2,600 to 6,900 miles from 1936 to 1952, whereas the length supported by timber and other means has decreased from 6,200 to 3,400 miles in the same period. This trend is reflected in the second part of the table, where the percentage of total roadways supported by steel has increased from 37 per cent. to 70 per cent., while timber and other supporting methods have decreased from 46 per cent. to 24 per cent. in the sixteen years.

Unfortunately, records do not appear to be available of the number of wooden props in use at the working face during the same period, for comparison with the steel props shown in the third part of the table. However, the Statistics Division of the Ministry of Fuel and Power have been able to provide figures of the number of wooden props in use in 1951 and 1952.

It will be observed that about three times the quantity of steel props were in use from 1949 to 1952 compared with the year 1936, but that in the last few years the total number has shown relatively little increase, probably owing to the shortage of steel supplies. More wooden props were in use in 1952 than in 1951, but only led steel in the ratio of approximately five wooden to four steel props in use.

* *Statistical Year Book*, 1952: British Iron and Steel Federation.

As at June 30	1936	1938	1949	1950	1951	1952
Length of roadways in use below ground supported by :	Thousand Miles					
Steel arches	2·6	3·2	5·6	6·1	6·5	6·9
Girders, bars, etc.	2·4	2·8	2·9	2·9	2·9	2·9
Timber and other means	6·2	6·3	3·8	3·6	3·6	3·4
Unsupported	2·4	2·3	1·1	1·0	0·9	0·9
TOTAL	13·6	14·6	13·4	13·6	13·9	14·1
Proportion of total roadways supported by :	Per Cent.					
Steel	37	41	64	66	68	70
Timber and other means	46	43	28	27	26	24
Unsupported	17	16	8	7	6	6
In use at the working face :	Thousands					
Steel props	519·7	598·6	1,540·5	1,581·9	1,551·3	1,684·0
Steel bars or straps	361·3	437·6	1,258·6	1,215·5	1,092·8	1,135·8
Wooden props and bars	No data	No data	No data	No data	1,697·3	2,072·6*

* Of this quantity, wooden props numbered 1,614·8 and wooden bars 457·8 in the year 1952.

BENEVOLENT FUND OF THE I.E.E.

President's Appeal to Members

It is the practice of each succeeding President of the Institution of Electrical Engineers to make an appeal to the members for contributions to the Incorporated Benevolent Fund of the Institution. In the course of his message continuing this custom, Mr. H. Bishop, the President for 1953-54, states that the fund "has the greatest difficulty in making ends meet." This point, which is illustrated by the fact that last year the fund paid out £280 more than it received, is not to the credit of the membership as a whole.

As Mr. Bishop says, an average contribution per member of 6*s.* 4*d.* is a disappointing figure. This small sum is not to be explained by the size of the individual contributions but by the fact that two-thirds of the very large number of members do not at present subscribe. Some satisfaction is to be obtained from the fact that subscriptions and donations last year rose to £12,155 compared with the £11,245 of the year before. Even so, however, investments had to be sold to meet the cost of development of "The Chesters," the residential estate comprising sixteen houses occupied by aged members of the Institution who have fallen on evil times, or their dependants.

Subscribers to the fund need not suppose that the money available is dissipated in extravagant grants. Mr. Bishop gives brief particulars of eight assisted cases. The average grant is less than £2 a week, which is a small sum in view of present-day living costs, and the average age of six of the recipients is over 72. The two somewhat younger are a widow and a daughter of deceased associate members left with small children. Members of the Institution of Electrical Engineers, in common with other people, receive many appeals from charities at Christmas time, but support for the activities of their own institution might well be placed first.

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DEVELOPMENTS IN POWDER METALLURGY

A course of eleven lectures dealing with many aspects of powder metallurgy will be delivered at the Battersea Polytechnic on Tuesday evenings beginning on January 12. Each lecture will commence at 7 p.m., and will be followed by a discussion. Subjects dealt with will include the preparation of ferrous and non-ferrous powders, their properties and methods of measurement, pressing and sintering, production of structural components, cemented carbides, molybdenum and tungsten, metal-ceramics, magnetic and electrical products, and recent work on beryllium and zirconium. The fee for the course will be 25*s.* and application should be made to the secretary (powder metallurgy course), Battersea Polytechnic, London, S.W.11.

ELECTRIC LIFTS IN BLOCK DWELLINGS

A paper read by Mr. C. G. L. Morley before the Utilisation Section of the Institution of Electrical Engineers on Thursday, December 10, 1953, reviewed present practice with regard to the electric passenger lifts installed in block dwellings of four or more storeys. The provision of single-speed passenger lifts for this purpose was, he said, now usual. This policy did not encourage the building of common shafts containing two or more lifts, as would be preferable for maintenance and overall serviceability. Generally speaking, the lifts installed on the London County Council's estates had a floor area of 16 sq. ft. and a carrying capacity of eight persons. Lifts to carry two, three, five and six persons had also been installed for special reasons, but the small saving in cost was outweighed by the reduced convenience.

The motor rooms were normally sited at the top of the shafts, an arrangement which decreased the load carried by the structure by about 40 per cent. and led to lower maintenance costs and reduced fire risk. In their construction special attention should be paid to the elimination of dust which, if it settled on the oiled surface of the guides, could seriously affect the wear of the car and counterweight shoes and give rise to noise. A lifting beam capable of hoisting any part of the winding engine and of suspending the car during re-roping should be installed. Natural light and ventilation should be provided and the windows should be arranged so that direct sunlight did not fall either on the lift mechanism or the electrical equipment. Accessibility to the equipment was essential, to secure which a minimum height of 7 ft. from floor to ceiling in the motor room was recommended.

PRECAUTIONS AGAINST MISUSE

To guard against misuse careful thought had been given to the materials and finish for the cars and architraves. It was finally decided to use an alloy of aluminium and manganese for the car linings, doors and architraves. This was fluted or ribbed lengthwise at intervals of about ¼ in. so that marks were not very apparent and no disfiguring rust appeared. The fluted surface was also a deterrent to writing. All the fixing screws were inaccessible either from the landings or the interior of the car and solid single-panel doors, which were both opened and closed by power, were used, both to protect children and as a safeguard against damage to the mechanical locks, such as might be caused by door slamming. When the lift had reached a landing, to which it had been called, both the landing and lift doors were opened and the leads to all the landing and car push-buttons were disconnected. After an interval of some seconds the car push-buttons were re-connected, the delay ensuring against the rapid reversal of lift travel which was one form of misuse. After 15 to 20 seconds a second control connected a feed to the landing push-button circuit, thus giving priority to a passenger who had called the lift. When this second device operated the doors were automatically closed, even though no call had been made. The car was then available for a call from any landing.

A " sensitive edge " was fitted to both car and landing doors. This depressed a switch so that the door-operating motor was reversed if an obstruction was encountered during closing. This arrangement necessitated the high-speed portion of the door-operating motor and the relays in its circuit being made as light as possible. The lift control circuit operated at 100 volts, thus reducing the size of the relays and providing a fair degree of protection against shock.

The car control station consisted of a hinged panel which was secured by two or more locks operated by keys. The push buttons were mounted on a block, which was so arranged that when the panel was closed they alone projected through it. In the locked position the panel also locked the cover of a junction box, which extended to the car floor and in which the flexible trailing cables terminated. These cables ran uninterruptedly from the car to the motor room and could be tested either from the floor of the car or the motor room. The omission of a terminal box in the lift well eliminated one source of trouble from loose connections. Considerable experience had been obtained with units in which the motor was coupled to the reduction gearing through V-ropes. This permitted a reduction in floor area and meant that less attention could be given to the alignment of the motor and gearing. The replacement of a burnt-out motor was also easier.

EMERGENCY STOP BUTTONS ELIMINATED

Silent operation had been assisted by the elimination of tappet switches from the lift well for floor selection and their replacement either by a mechanical switch, driven by a tape or chain from the lift car, or a selector system in the control panel, which was operated by electrical impulses. No emergency stop button was provided in the cars, since with solid doors it was considered it served little useful purpose, as obstructions in the well could not be seen. A mechanical lock was, however, fitted on the door so that a passenger could not forcibly open it and stop the car.

A control station was fitted on the roof of the car to enable the lift well to be inspected. This contained a selector switch which enabled the mechanic to obtain complete control of the car travel. " Up " and " down " push buttons were also provided for operating the car provided all the safety locks were appropriately set. The release of these buttons caused the lift to stop immediately. A circuit-breaker was installed in a prominent position in the motor room to facilitate prompt action in emergency. This was supplied through fuses, which were housed in a locked distribution box if several lifts were installed. If there was only one a switch-fuse was used. An alarm push button for operating a bell near the ground-floor landing door was provided at the car control station and was wired from the motor-room lighting circuit, this being separated from other circuits in the roof space. By the side of the bell was a notice lettered " lift breakdown " to indicate that a passenger in the car required assistance.

FIRE PRECAUTIONS

In block dwellings the height of which exceeded 80 ft., it was necessary for one lift to be nominated as a " fireman's lift." This required a separate electricity supply and modifications to the control circuit, so that the operation of a switch at the ground-floor level would stop the car or cause it to descend to the ground floor. The sole control of the car had to be vested in the fireman, which meant that the landing push buttons must be rendered inoperative.

A common form of misuse was the introduction of foreign matter into the track at the bottom of the doors. To prevent the closing motor operating in this condition a timing device had been introduced which would shut it down after one minute. As the doors might continuously open and reclose if an obstruction operated the " sensitive edge," another device held the doors fully open after this cycling had continued for two minutes.

RADIANT HEAT TREATMENT OF NYLON FABRICS

If fabrics woven or knitted from nylon, Terylene and similar synthetic fibres are to have dimensional stability, softness, drape and freedom from edge-curling the strains set up during manufacture must be relaxed by heat, thus allowing the freed molecules to re-orientate themselves in the required finished direction. Although high-pressure steam and hot gas have been used for this purpose, in the case of nylon there is a demand for smaller equipment which will give rapid results. The General Electric Company, Limited, Kingsway, London, W.C.2, in collaboration with British Nylon Spinners, Limited, 25, Upper Brook-street, London, W.1, and George Pearson and Sons, Limited, Nottingham, have therefore designed radiant heating plant for this purpose.

The plant consists of a horizontal bank of sheathed-wire element reflector troughs, 3 ft. long, which are mounted in an angle iron framework and vary in number according to conditions. For instance, a plant 6 ft. long will process 14 yards of nylon fabric per minute. The element troughs, which are about 11 in. wide, run roughly parallel with the direction of the cloth and are enclosed in aluminium reflector sheets about 12 in. deep. Reflector sheets are also placed at the bottom of the bank. Control is effected from a separate panel, the electrical loading being about 1·2 kW per square foot. To ensure the consistent and accurately controlled setting of the fabrics the heating elements must be supplied at a fairly constant voltage, to obtain which a transformer may be necessary.

The equipment can be fitted over existing stenters and suspended from the roof, arrangements being made so that it can automatically be raised from the cloth surface should over-heating occur. Long pre-heating is unnecessary since the equipment reaches its full thermal intensity in 5 to 10 minutes. The setting temperature is also reached very quickly—in about eight seconds in the case of most lightweight fabrics—owing to the rapid transfer of heat from the radiant source. The insertion of heat-resisting glass in the side panels enables the material to be kept under continuous observation.

Experience shows that there is no deterioration in the strength of the fabric or reduction in the physical qualities of the fibres when this method is used. The resulting uniformity of setting also gives an even level of dyeing. No discoloration occurs, since the cloth is only at a high temperature for a very short time, and there is no oxidation of the fibres owing to the negligible air flow. The use of anti-oxidants and bleaching is therefore unnecessary.

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APPRENTICESHIP WITH BRITISH RAILWAYS

The training of young men as craftsmen is one of the most important responsibilities of the community, and in so far as British Railways is concerned, is one which is shouldered with vigour and efficiency. An attractive and well-illustrated brochure dealing with apprenticeship with British Railways is now available to would-be apprentices, parents and educational authorities, and in it is set out the progressive system of workshop training in operation at the Derby works of the London Midland Region. The system provides four months' initial training during which a trainee receives 12 hours of theoretical and 27 hours of practical instruction a week, followed by a planned apprenticeship which opens the way for an able boy, ultimately to reach the highest executive positions in railway engineering.

LAUNCHES AND TRIAL TRIPS

M.S. "MUNKEDAL."—Single-screw oil tanker, built and engined by the Götaverken Shipyard, Gothenburg, for Munkedals A/B, Munkedal, Sweden. Main dimensions: 550 ft. overall by 66 ft. by 39 ft. 3 in.; deadweight capacity, about 17,600 tons on a draught of 30 ft. 2 in. Götaverken nine-cylinder single-acting two-stroke Diesel engine, developing 6,750 b.h.p. at 112 r.p.m., and a speed of 15 knots, fully loaded. Launch, November 10.

S.S. "NORTH QUEEN."—Single-screw cargo vessel, built by Short Brothers, Ltd., Sunderland, for Mr. A. G. Pappadakis, London, E.C.3. Third vessel built for this owner. Main dimensions: 438 ft. between perpendiculars by 59 ft. 6 in. by 37 ft. 7 in. to shelter deck; deadweight capacity, about 9,895 tons on a draught of 25 ft. 9½ in. Triple-expansion steam engine of reheat design, and three multi-tubular oil-burning boilers, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Service speed, 12 knots. Trial trip, November 11.

M.S. "SUDAN."—Twin-screw cargo vessel, with accommodation for twelve passengers, built and engined by the Eriksbergs Mek. Verstads Aktiebolag, Gothenburg, for A/B Svenska Ostasiatiska Kompaniet, Gothenburg, Sweden. Main dimensions: 470 ft. between perpendiculars by 65 ft. by 40 ft. 6 in. to shelter deck; deadweight capacity, 10,550 tons on a draught of 27 ft. 3½ in. Two six-cylinder single-acting two-stroke Diesel engines, together developing 12,000 i.h.p. Speed, 17½ knots, fully loaded. Delivered, November 18.

M.S. "JARENA."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Belfast, for Anders Jahre & Co., Sandefjord, Norway. Fourth of a series of five similar vessels for these owners. Main dimensions: 540 ft. between perpendiculars by 73 ft. by 39 ft. 3 in. to upper deck; deadweight capacity, about 18,500 tons. Harland-B. and W. six-cylinder two-stroke single-acting opposed-piston oil engine. Trial trip, November 18.

LIGHT VESSEL No. 15.—Built by Philip and Son, Ltd., Dartmouth, for the Corporation of Trinity House, London, E.C.2. Twenty-third light vessel constructed for the Corporation. Main dimensions: 130 ft. by 25 ft. by 15 ft.; gross tonnage, 350. The lantern contains six 500-watt lamps, giving a beam visible for from 10 to 12 miles in clear weather. Launch, November 18.

S.S. "WALLASEY."—Single-screw tug, built by Cochrane and Sons, Ltd., Selby, Yorkshire, for the Alexandra Towing Co., Ltd., Liverpool. Main dimensions: 92 ft. 6 in. by 25 ft. 6 in. by 12 ft. 6 in.; gross tonnage, 200. Triple-expansion steam engine, constructed by Charles D. Holmes & Co., Ltd., Hull. Launch, November 23.

S.S. "BRITISH ENGINEER."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Belfast, for the British Tanker Co., Ltd., London, E.C.2. Main dimensions: 665 ft. overall by 85 ft. 6 in. by 46 ft. 8 in.; deadweight capacity, about 32,000 tons. Compound steam turbines with double-reduction gearing, developing 12,500 s.h.p. at 112 r.p.m. Launch, November 24.

M.S. "LA CHACRA."—Single-screw cargo vessel, built by Bartram and Sons, Ltd., Sunderland, for Buries Markes, Ltd., London, E.C.3. Main dimensions: 440 ft. between perpendiculars by 60 ft. 6 in. by 38 ft. 4 in. to shelter deck; deadweight capacity, 9,500 tons on a summer draught of 26 ft. 0½ in. N.E.M.-Doxford five-cylinder two-stroke opposed-piston heavy-oil engine, developing 5,500 b.h.p. at 115 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Service speed, 14½ knots. Trial speed, 16·21 knots. Trial trip, November 24.

S.S. "ARIANA."—Single-screw cargo vessel, built and engined by William Gray & Co., Ltd., West Hartlepool, for Rederibolget Re-Be, Abo, Finland. Main dimensions: 406 ft. between perpendiculars by 56 ft. by 36 ft. 4½ in. to shelter deck; deadweight capacity, 8,700 tons on a draught of 24 ft. 11½ in. Triple-expansion steam engine working in conjunction with a Bauer-Wach exhaust turbine, constructed at the shipbuilders' Central Marine Engine Works. Steam supplied by two oil-fired boilers. Service speed, about 11½ knots. Trial trip, November 25.

S.S. "HERTHA."—Single-screw oil tanker, built and engined by the Blythswood Shipbuilding Co., Ltd., Scotstoun, Glasgow, for S.A. William Hansens Rederi, Bergen, Norway. Main dimensions: 305 ft. by 44 ft. by 20 ft. 3 in. to upper deck; deadweight capacity about 3,500 tons on a draught of 18 ft. 6 in. Triple-expansion steam engine. Launch, November 26.

Labour Notes

INCREASED RAILWAY CHARGES?

Immediate efforts are likely to be made by the British Transport Commission to balance the additional expenses which the Commission are being called upon to meet. Besides advances in railway freights and dock charges, there are expected to be some increases in passenger fares in the London district and elsewhere. It was made known, however, after a meeting of the Commission on December 18, at which General Sir Brian Robertson presided, that long-distance and holiday fares are not expected to be affected.

The Commission decided that they would not be able to absorb the increased costs with which they were faced unless charges generally were raised. Freights were expected to be advanced by 10 per cent. In this connection, it may be recalled that an increase of 5 per cent. in these charges in 1952 produced an extra £12 million in revenue.

Railway expenses rose steadily all through 1953, beginning with the higher prices charged for coal early in the year and ending with the wage increase conceded last month.

While the suggested increases in charges will take into account the immediate rise of 4*s.* a week in wages, they are not expected, at all events at present, to provide for the further percentage increase, over and above that amount, which is expected to be approved within the next few weeks. During the negotiations with the unions towards the end of last month, the Commission stated that they hoped that these extra increases in wages would result in economies and greater efficiency.

EXAMINATION OF RAILWAY WAGE STRUCTURE

Preliminary discussions on the wage and salary structure of the railway industry took place at a meeting between representatives of the British Transport Commission and the three principal railway unions on December 22, held in accordance with the agreement reached in the previous week when it was decided that the two sides should meet to examine earnings, correct anomalies and arrange for the provision of further incentives. It was as a result of that agreement that the National Union of Railwaymen cancelled the national strike which had been ordered to commence on December 21.

The meeting was of short duration and only the main lines along which the consideration of these problems are to proceed were discussed. An official statement issued subsequently mentioned that agreement was reached on this point, and that a further joint meeting between representatives of the Commission, the N.U.R., and the other two unions, the Transport Salaried Staffs' Association and the Associated Society of Locomotive Engineers and Firemen, would take place early this month.

One of the first steps to be undertaken at the coming meeting will be to settle the amount of the percentage increase in standard wage and salary rates which the Commission promised to introduce not later than the first week in February. In this connection, Mr. J. S. Campbell, the general secretary of the N.U.R., made it clear, when the strike was called off, that the percentage increase referred to must give the lowest-paid railwaymen at least 3*s.* weekly, in addition to the 4*s.* a week provided by the Railway Staff National Tribunal's award of December 4. Otherwise, the union would regard the additional sum as unacceptable.

SEAFARERS' WAGES

Adult ratings in the British mercantile marine were awarded an increase of 30*s.* a month, equivalent to about 7*s.* a week, at a meeting of the National Maritime Board on December 18. Boys will receive a proportionate increase and a rather larger sum will be granted to petty officers. Increases for the officer grades will be based on the award to adult ratings and will range upwards from 30*s.* a month for newly-appointed junior uncertificated officers.

In all, about 145,000 officers and men of the Merchant Navy will benefit from the increases, which are the first to be granted to the service since January, 1952. The award was made in reply to claims for a substantial advance in wages submitted by the seafarers' organisations on November 19. The Board, which comprises representatives of both shipowners and the trade unions, agreed that the rises should be worked out in detail at a later date, but that they should become effective as from January 25 next.

Existing rates of pay for able-bodied seamen commence at £24 a month, with all food provided. In addition, an efficient-service allowance of £1 a month may be earned each year for four years, thereby bringing the pay of efficient ratings up to £28 a month. Such men will receive £29 10*s.* a month in future. At present, able-bodied seamen employed on a weekly basis receive £6 14*s.*, rising to £7 12*s.* 8*d.* after four years' efficient service.

NATIONAL COAL BOARD "COMPLACENT"

Suggestions that undue complacency was being shown by the National Coal Board respecting the urgency of the miners' wage claim were made at a meeting of the South Wales area executive committee of the National Union of Mineworkers on December 22. The union has presented demands for an increase of 12*s.* 6*d.* a week in the minimum rates for surface employees and of 13*s.* 6*d.* a week for men employed underground. These will be discussed at a meeting in London between officials of the two sides next Tuesday.

Mr. Will Paynter, President of the union's South Wales area, said that strong dissatisfaction was felt at the slow progress of the wage negotiations. Miners throughout the industry were anxious that a decision should be reached when the joint meeting took place, and those belonging to the South Wales area were in favour of a national delegate conference being summoned to consider a report on the discussions. Meetings and demonstrations would be held in all parts of the South Wales coalfield if the Board failed to concede the union's claims in their entirety.

Mr. Paynter added that members of the area executive committee were being subjected to considerable pressure from many of the miners' lodges to take active steps to enforce the wage claims, either in the form of banning all Saturday work and overtime, or by direct strike action. The committee were, in fact, much concerned at the rather startling proportions to which the working of overtime had grown. This was definitely contrary to the objects of the union, which was anxious to return to a genuine five-day working week throughout the industry.

Production results achieved by the industry during the week ended December 19, 1953, were the highest since the Dunkirk period in June, 1940, according to provisional statistics issued by the Ministry of Fuel and Power just before Christmas. Although it is traditional for miners to work harder during the pre-Christmas period, output in the week referred to, 4,772,200 tons of deep-mined coal and 230,700 tons of opencast coal, is regarded officially as most encouraging.

NOTICES OF MEETINGS

British Institution of Radio Engineers

LONDON
"Engineering Design of Very-High-Frequency Multi-Channel Telephone Equipment," by W. T. Brown. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Jan. 6, 6.30 p.m.

EDINBURGH
"Radio Astronomy," by H. Seddon. Scottish Section. Department of Natural Philosophy, Edinburgh University. Thurs., Jan. 7, 7 p.m.

LIVERPOOL
"Interlacing Problems in Television Receivers," by Dr. G. N. Patchett. Merseyside Section. Electricity Service Centre, Whitechapel, Liverpool, 1. Thurs., Jan. 7, 7 p.m.

MANCHESTER
"Manchester University Computor," by D. B. G. Edwards. North-Western Section. College of Technology, Manchester. Thurs., Jan. 7, 7 p.m.

Incorporated Plant Engineers

LONDON
"Transmission Equipment and Bearings," by F. J. Walters. Royal Society of Arts, John Adam-street, W.C.2. Tues., Jan. 5, 7 p.m.

EDINBURGH
"Power Factor Correction," by Hugh Ferguson. 25 Charlotte-square, Edinburgh. Tues., Jan 5, 7 p.m.

PETERBOROUGH
"Industrial Uses of Magnetic Power," by G. T. Hawker. Eastern Gas Board's Offices, Church-street, Peterborough. Thurs., Jan. 7, 7.30 p.m.

SOUTHAMPTON
"History of Southampton's Water Supply," by Joseph Hawksley. Polygon Hotel, Southampton. Wed., Jan. 6, 7.30 p.m.

Institute of British Foundrymen

BRADFORD
"Aluminium Casting Alloys," by R. Mercer. West Riding of Yorkshire Branch. Technical College, Bradford. Sat., Jan. 9, 6.30 p.m.

GLASGOW
"Core Assembly as a Production Aid to the Jobbing Foundry," by E. H. Beech and J. Hoyes. Scottish Branch. Royal Technical College, Glasgow. Sat., Jan. 9, 3 p.m.

LINCOLN
"Aluminium Pattern Equipment by the Pressure Cast Plaster Process," by D. H. Potts. Lincolnshire Branch. Lincoln Technical College, Lincoln. Thurs., Jan. 7, 7.15 p.m.

NEWCASTLE-UPON-TYNE
"Residual Stresses in Castings," by Dr. R. N. Parkins. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Sat., Jan. 9, 6 p.m.

SHEFFIELD
"Examples of Loam Moulding as Applied to Production of Pump Castings and Impellors," by E. Clipson. Sheffield College of Commerce and Technology, Pond-street, Sheffield, 1. Mon., Jan. 4, 7.30 p.m.

Institute of Fuel

BRIDGEND
"Extension at Llandarcy," by F. V. M. Bell. South Wales Section. Technical College, Bridgend. Fri., Jan 8, 6 p.m.

NEWCASTLE-UPON-TYNE
"Calorific Value of Coal," by J. Brown. North-Eastern Section. King's College, Newcastle-upon-Tyne. Mon., Jan. 11, 6.30 p.m.

Institute of Metals

LONDON
"Rogerstone Strip Mill," by F. King. London Local Section. Thurs., Jan. 7, 6.30 p.m.

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PROTECTING METALS BY PAINTING

A series of eight lectures will be delivered at the Battersea Polytechnic on Thursday evenings, beginning on January 28, on topics relating to the protection of metals by painting. The lectures, which will commence at 7 p.m., will be delivered by a panel of seven lecturers and are being arranged in conjunction with the Corrosion Group of the Society of Chemical Industry, and the Oil and Colour Chemists' Association. Subjects dealt with will include the preparation of metals for painting, painting for outdoor and immersed service, inspection, cleaning, maintenance, and the testing of paint coatings. Applications to attend should be made to the secretary (paints course), Battersea Polytechnic, London, S.W.11. The fee is 20s.

There will be an exhibition of protective methods for preventing the corrosion of steel at the Polytechnic on Friday, January 22, from 10 a.m. until 5 p.m.

BIRMINGHAM
"Lubricants for Metal-Working Operations in the Non-Ferrous Metals Industries." Informal Discussion. The University, Edgbaston, Birmingham, 15. Wed., Jan. 6, 10.30 a.m.

OXFORD
"Industrial Methods of Electroplating," by Dr. G. E. Gardam. Cadena Café, Cornmarket-street, Oxford. Tues., Jan 5, 7 p.m.

Institution of Civil Engineers

LONDON
"Swedish Underground Hydro-Electric Power Stations," by J. F. Hagrup. Works Engineering Division. Tues., Jan. 5, 5.30 p.m.

Institution of Electrical Engineers

LONDON
"A Scaling Unit Employing Multi-Electrode Cold-Cathode Tubes," by K. Kandiah; "A Sensitive Pulse Trigger Circuit with a Stable Threshold," by K. Kandiah; "The Development of a Neutron Spectrometer for the Intermediate Energies," by F. S. Goulding, J. C. Hammerton, M. G. Kelliher, A. W. Merrison and E. R. Wiblin. Measurements Section. Tues., Jan 5, 5.30 p.m.
"Continuity of Electricity Supply," by H. Leyburn. Parsons Memorial Lecture. Thurs., Jan. 7, 5.30 p.m.
Film Evening. London Students' Section. Mon., Jan. 11, 7 p.m.

BIRMINGHAM
"Technical Education of Other than National Certificate Students." Discussion opened by J. Ashmore and D. I. Meyrick. South Midland Centre. James Watt Memorial Institute, Birmingham. Mon., Jan 4, 6 p.m.

HOVE
"Operation of Power Transformers," by E. T. Norris. Southern Centre. South Eastern Electricity Board's Offices, Hove. Wed., Jan. 6, 6.30 p.m.

IPSWICH
"Modern Developments in Atomic Energy," by Dr. T. E. Allibone. District Meeting. Crown and Anchor Hotel, Ipswich. Mon., Jan. 4, 6.30 p.m.

LEEDS
"Voltage Transformers and Current Transformers Associated with Switchgear," by W. Gray and A. Wright. North Midland Centre. Yorkshire Electricity Division's Offices, 1 Whitehall-road, Leeds. Tues., Jan. 5, 6.30 p.m.

LIVERPOOL
"Electronic Telephone Exchanges," by T. H. Flowers. Mersey and North Wales Centre. Liverpool Royal Institution, Colquitt-street, Liverpool. Mon., Jan. 4, 6.30 p.m.

MANCHESTER
"Co-Ordination of Insulation of High-Voltage Electrical Installations," by J. S. Cliff. North-Western Centre. Engineers' Club, Manchester. Tues., Jan. 5, 6.15 p.m.

Institution of Mechanical Engineers

LONDON
"Modern Thermal Power Stations," by R. C. Nicoll and J. Griffin. London Graduates' Section. Tues., Jan. 5, 6.30 p.m.
"Experimental Investigation into the Effect of Fuel Addition to the Intake Air on Performance of a Compression-Ignition Engine," by W. T. Lyn; and "Effect of Auxiliary Fuels on the Smoke-Limited Power Output of Diesel Engines," by L. D. Derry, Dr. E. M. Dodds, Dr. E. B. Evans and D. Royle. Institution Meeting in conjunction with Internal Combustion Engine Group. Fri., Jan. 8, 5.30 p.m.
"Two-Stroke Automotive Compression-Ignition Engines," by Professor Hans List. Automobile Division. Tues., Jan. 12, 5.30 p.m.

NEWCASTLE-UPON-TYNE
Annual General Meeting. North-Eastern Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Jan. 4, 6 p.m.

Institution of Production Engineers

BRISTOL
"Management and the Law," by H. P. Jost. Western Graduate Section. Grand Hotel, Broad-street, Bristol, 1. Mon., Jan. 11, 7.30 p.m.

CARDIFF
"Increased Productivity by the Use of Compressed Air," by C. M. P. Willcox. South Wales and Monmouthshire Section. South Wales Institute of Engineers, Park-place, Cardiff. Thurs., Jan. 7, 6.45 p.m.

COVENTRY
Film Evening. Graduate Section. Hare and Squirrel Hotel, Cow-lane, Coventry. Tues., Jan. 5, 7.30 p.m.

IPSWICH
"Production of Woven Artificial-Silk Fabrics," by [illegible] H. Boas and N. Ray. Eastern Counties Section. Diocesan Hall, Tower-street, Ipswich. Fri., Jan. 8, 7.30 p.m.

NOTTINGHAM
"Production Engineer and His Relations," by J. H. Bingham. Victoria Station Hotel, Milton-street, Nottingham. Wed., Jan. 6, 7 p.m.

WOLVERHAMPTON
"Application of Hydraulic Power as an Aid to Productivity," by F. B. Levetus. Wolverhampton and Staffordshire Technical College, Wolverhampton. Wed., Jan. 6, 7.15 p.m.

Institution of the Rubber Industry

BIRMINGHAM
"What the Aircraft Manufacturer Wants from the Rubber Industry," by J. H. Cork. Midland Section. James Watt Memorial Institute, Birmingham. Mon., Jan. 11, 6.45 p.m.

LEICESTER
"Extruders and Extrusion," by H. C. Harrison. Bell Hotel, Leicester. Wed., Jan. 13, 7.30 p.m.

NEWCASTLE-UPON-TYNE
"Rubber and Ships," by Dr. W. J. S. Naunton. North-Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Jan. 4, 7 p.m.

PRESTON
"Role of Latex in the Rubber Industry," by E. W. Madge. Bull and Royal Hotel, Church-street, Preston. Mon., Jan. 11, 7.15 p.m.

Institution of Sanitary Engineers

LONDON
Presidential Address, by E. H. Vick. Caxton Hall, Westminster, S.W.1. Thurs., Jan. 7, 6 p.m.

Institution of Structural Engineers

BRISTOL
"Hangars at London Airport: Design of Long-Span Prestressed-Concrete Beams," by A. J. Harris. The University, University-road, Bristol. Fri., Jan. 8, 6 p.m.

Institution of Works Managers

NOTTINGHAM
"Problems of My Job." Open Discussion. Notts and Derby Branch. Welbeck Hotel, Nottingham. Fri., Jan. 8, 8 p.m.

Junior Institution of Engineers

LONDON
"A Modern Vehicle-Actuated Detector and Its Development," by H. J. N. Riddle. Townsend House, Greycoat-place, S.W.1. Fri., Jan. 8, 7 p.m.

BIRMINGHAM
"Brewing and Distilling." Chairman's Address, by T. F. Luck. Midland Section. James Watt Memorial Institute, Birmingham. Wed., Jan. 6, 7 p.m.

SHEFFIELD
"Clean City Air: An Engineer's Problem," by James Law. Livesey Clegg House, Union-street, Sheffield. Mon., Jan. 11, 7.30 p.m.

Manchester Association of Engineers

MANCHESTER
"Training of Designer-Draughtsmen." Discussion. Engineers' Club, Manchester. Fri., Jan. 8, 6.45 p.m.

Reinforced Concrete Association

LIVERPOOL & MANCHESTER
"Concreting Methods and Machinery," by A. P. Lambert. College of Technology, Manchester, Tues., Jan. 5, 6.45 p.m.; and 9 The Temple, 24 Dale-street, Liverpool, Wed., Jan. 6, 6.30 p.m.

Royal Aeronautical Society

LONDON
"The Fun of Finding Out in Flying," by Sir Leonard Bairstow. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, S.W.1. Lecture for Young People. Thurs., Jan. 7, 3 p.m.

Television Society

LONDON
"The Marconi Television O.B. Unit," by C. Carrington. Film House, Wardour-street, W.1. Wed., Jan. 6, 6.45 p.m.

The address of the headquarters of each Institution is given in the following list. Meetings held in the headquarters town are held at this address unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceeding the date of the meeting.

British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1.
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham.
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3.
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1.
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1.
Institution of Civil Engineers, Great George-street, London, S.W.1.
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2.
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, S.W.1.
Institution of Production Engineers, 36 Portman-square, London, W.1.
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1.
Institution of Sanitary Engineers, 118 Victoria-street, London, S.W.1.
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1.
Institution of Works Managers, 67-68 Chandos-place, London, W.C.2.
Junior Institution of Engineers, 39 Victoria-street, London, S.W.1.
Manchester Association of Engineers, 20 Booth-street, Manchester, 2.
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1.
Royal Aeronautical Society, 4 Hamilton-place, London, W.1.
Television Society, 164 Shaftesbury-avenue, London, W.C.2.